

G.I.-30 SEPT. 1976

GEOCRES No. 52B-6DIST. 19 REGION W.P. No. 18-77-07CONT. No. 80-454W. O. No. STR. SITE No. HWY. No. LocLOCATION Seine River DiversionNo of PAGES -OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.REMARKS:

DIST. NO. 19		SHEET
CONT No	No 19-77-07	
SEINE RIVER BRIDGE 10.4 Km. NORTH OF ATIKOKAN GENERAL LAYOUT		

CONCRETE QUANTITIES (For Loop 10m Model Items)

CONCRETE IN ABUTMENTS AND
WINDWALLS & PIER CAPS — 132.0 CU YD.
CONCRETE IN DECK — 135.0 CU YD.
CONCRETE IN BARRIER WALLS — 44.0 CU YD.
CONCRETE IN APPROACH SLABS — 35.4 CU YD.

STRUCTURAL STEEL QUANTITY — 90 TONNES

NOTES:

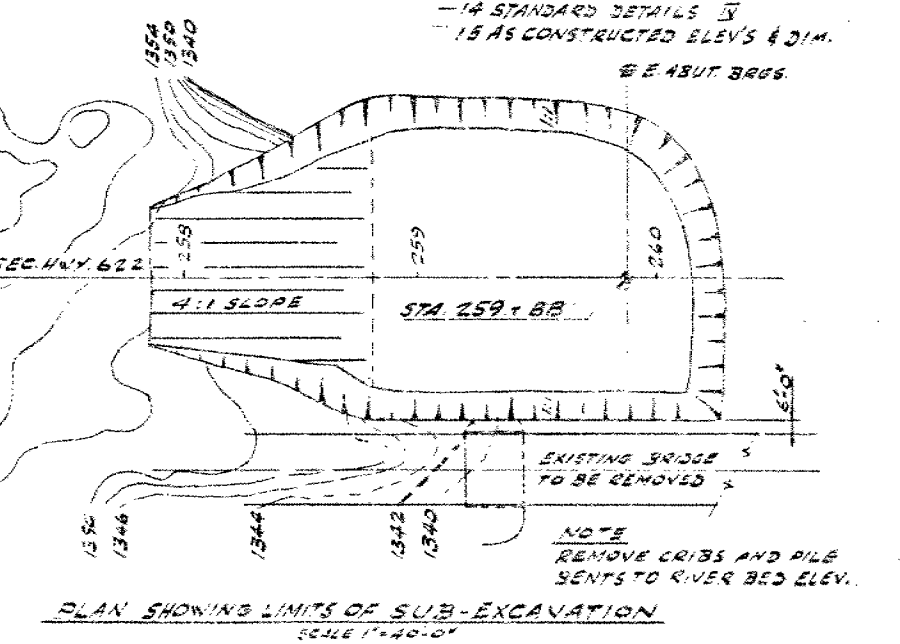
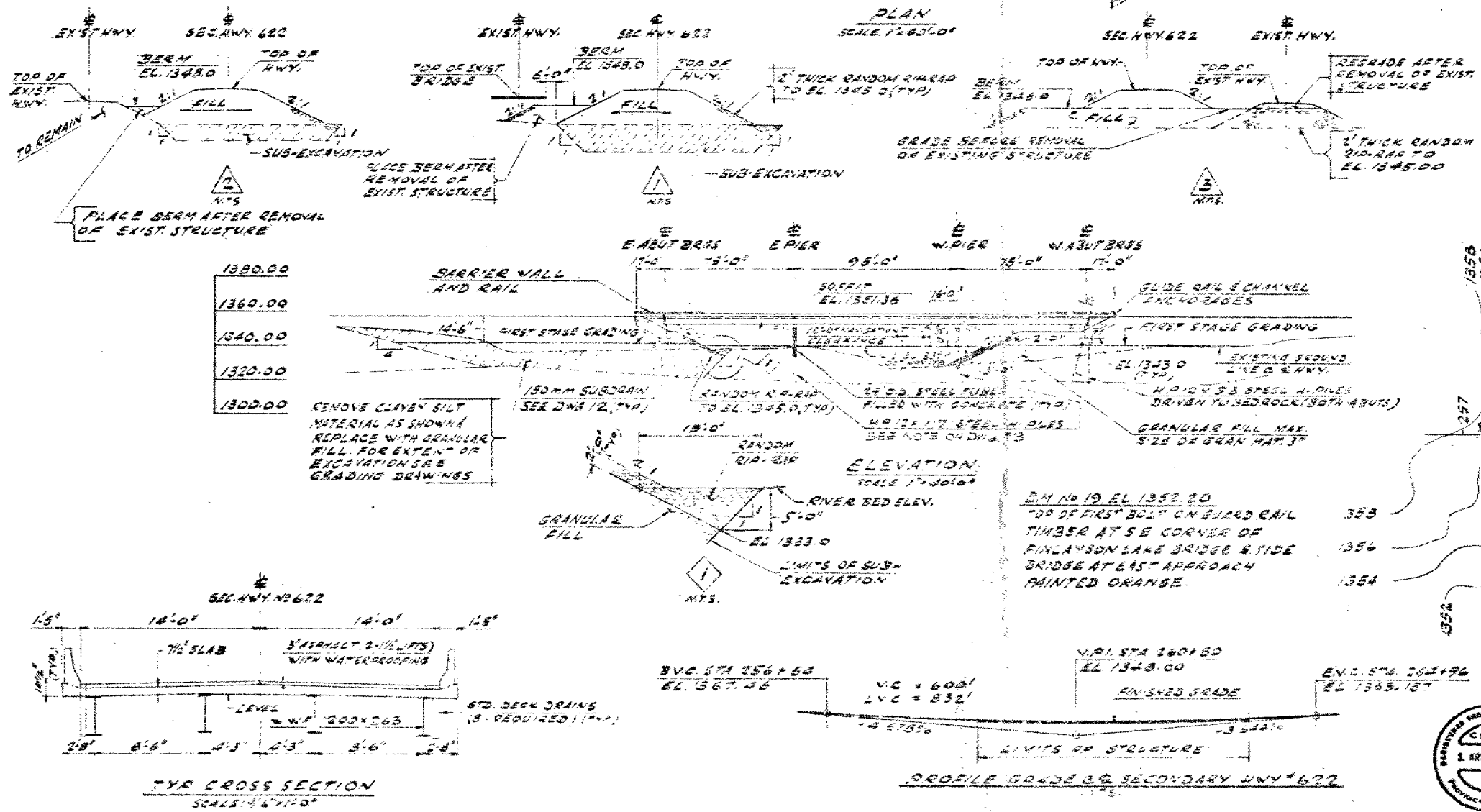
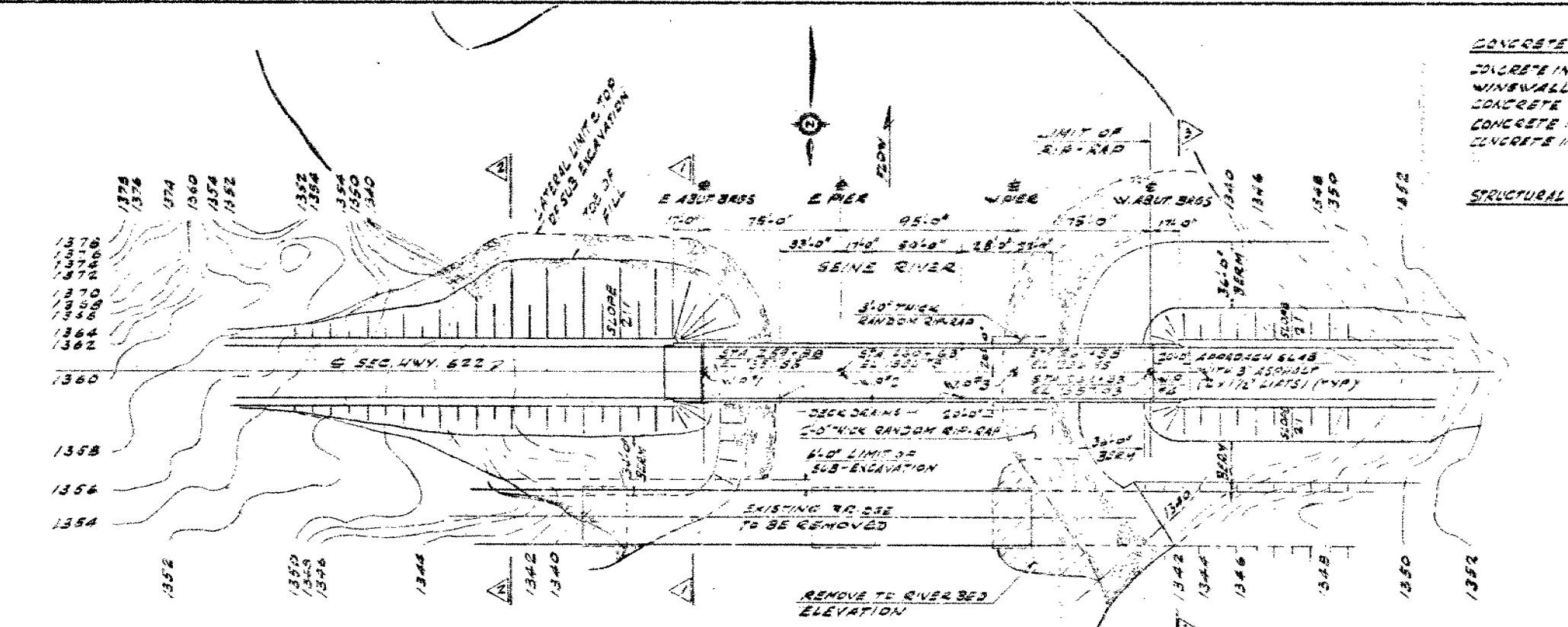
REINFORCING STEEL GRADE — 400
REINFORCING BARS WITH THE DESIGNATION 'S' AT THE
END OF BAR MARKS SHALL BE COATED BARS.

CLASS OF CONCRETE:
DECK & BARRIER WALLS — 30 M PA
REMAINDER — 20 M PA
AND/OR AS NOTED ON DRAWINGS.

CLEAR COVER TO REINFORCING STEEL:
FOOTINGS AND ABUTMENTS — 3", PIER CAP — 2"
DECK: TOP — 2", BOTTOM — 1 1/2" AND/OR AS
NOTED ON DRAWINGS.

CONSTRUCTION NOTES:
THE CONTRACTOR IS RESPONSIBLE FOR
FINISHING THE BEARING SEATS DEAD LEVEL TO THE
SPECIFIED ELEVATIONS WITH A TOLERANCE OF ± 1/8".
NO CONCRETE SHALL BE PLACED ABOVE THE
ABUTMENT BEARING SEATS UNTIL CONCRETE IN
DECK HAS BEEN PLACED.

- LIST OF DRAWINGS**
- 45-129 — 1 GENERAL LAYOUT
— 2 BOREHOLE LOCATION & SOIL STRATA
— 3 ABUT. FOOTINGS AND PIERS
— 4 EAST AND WEST ABUTMENTS
— 5 STRUCTURAL STEEL DETAILS
— 6 BEARINGS AND SPICE DETAILS
— 7 DECK DETAILS & REINFORCEMENT
— 8 BARRIER WALL
— 9 STEEL RAILING (SINGLE TUBE)
— 10 20 FT. APPROACH SLAB
— 11 STANDARD DETAILS I
— 12 STANDARD DETAILS II
— 13 STANDARD DETAILS III
— 14 STANDARD DETAILS IV
— 15 AS CONSTRUCTED ELEV'S & DIM.



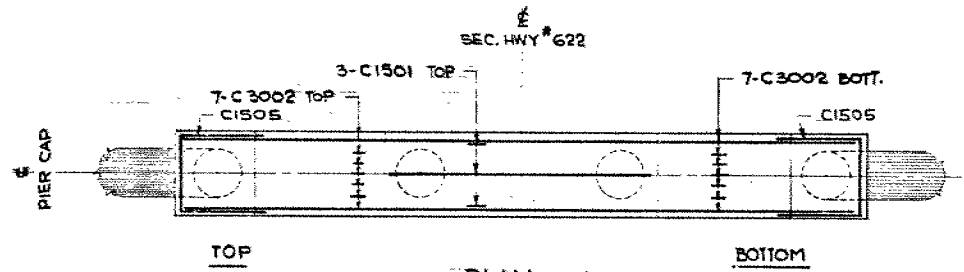
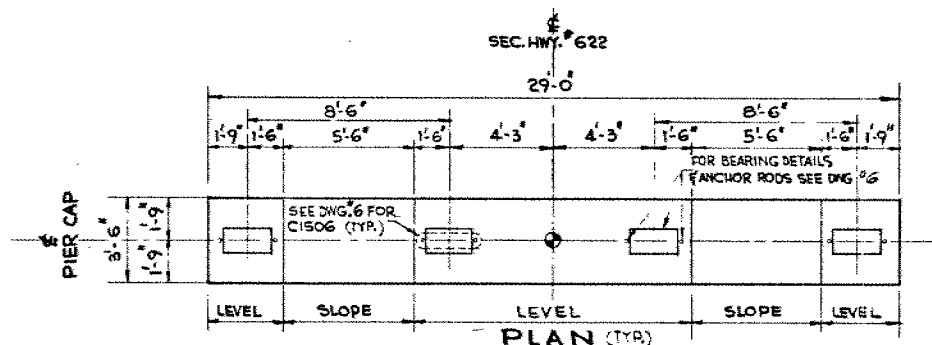
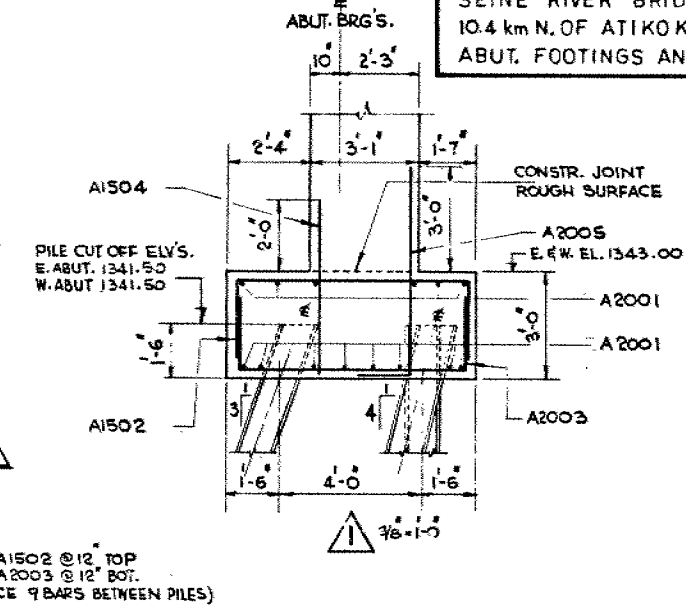
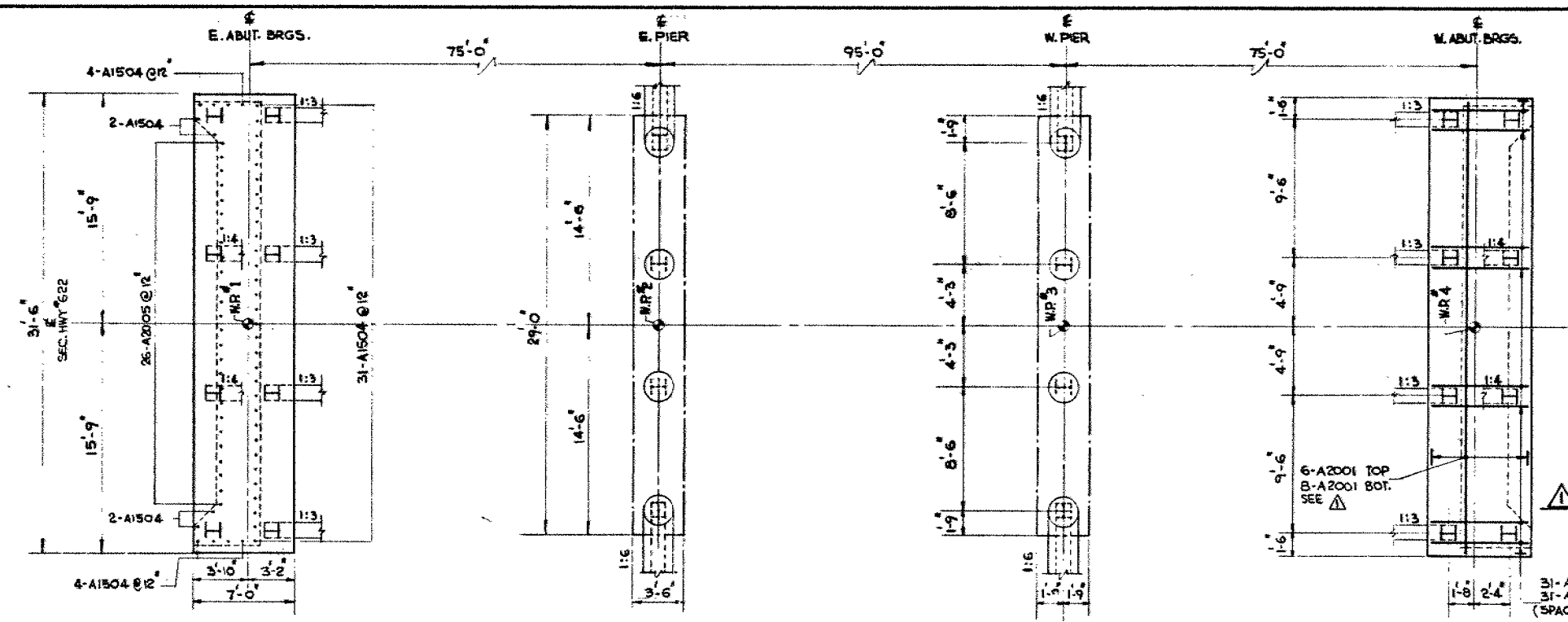
FOR REDUCED PLAN

USE SCALE BELOW

1" = 40' ON ORIGINAL PLAN

REVISIONS	DATE	BY	DESCRIPTION
1			
2			
3			

DESIGN: S.K. CHECK: J.L. LOADING: J.L. DATE: 1977-07-07
DRAWING: 17 CHECK: S.K. SITE No: 17 DWG: 17

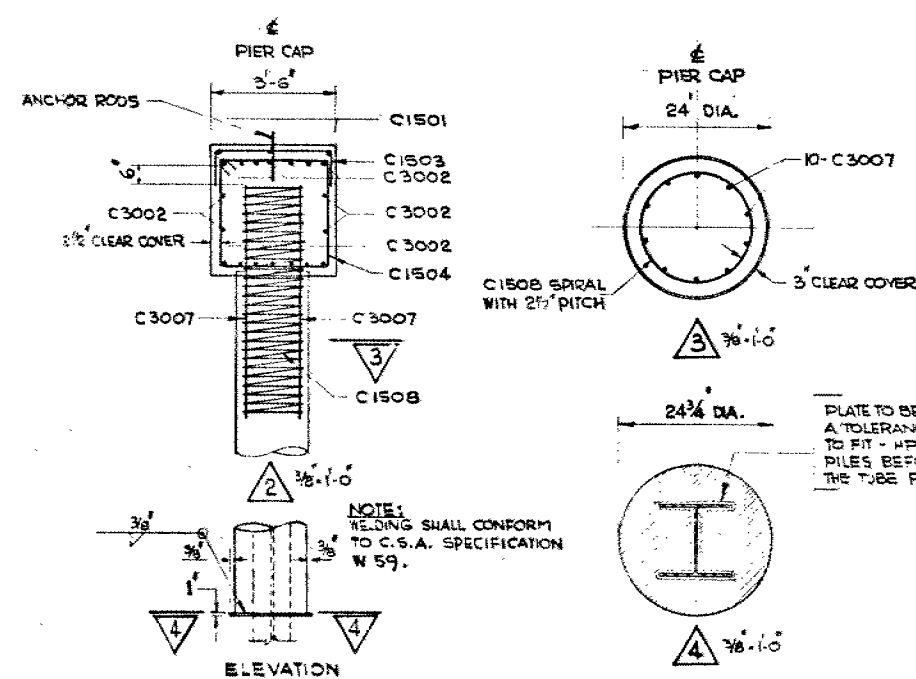
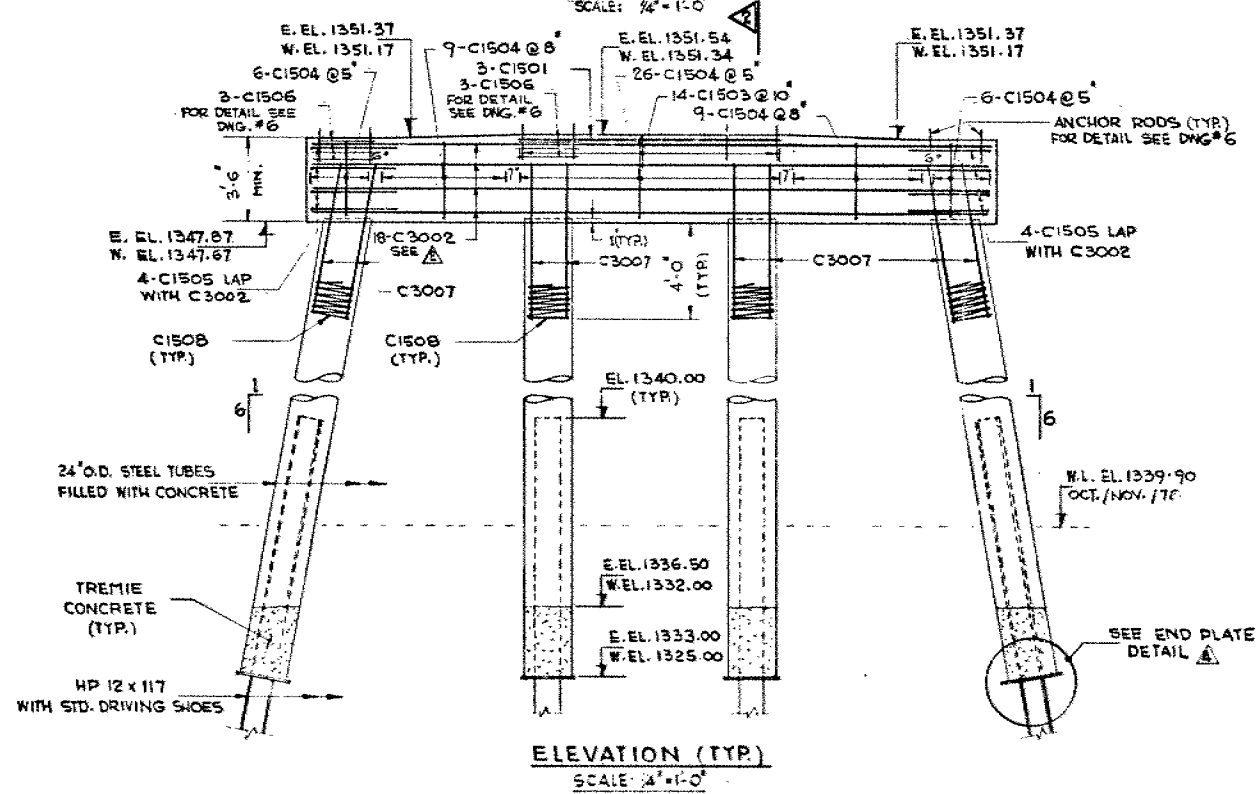


STEEL 'H' PILES				
LOCATION	TYPE	Nº REQ'D.	PILE LENGTH	REMARKS
E. ABUTMENT	HP 12 x 53	8	57'-0"	DRIVING SHOE
E. PIER	HP 12 x 117	4	57'-0"	DO
W. PIER	HP 12 x 117	4	50'-0"	DO
W. ABUTMENT	HP 12 x 53	8	69'-0"	DO

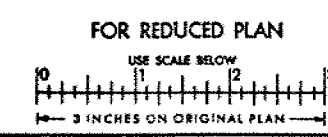
- NOTES:
- H-PILES TO BE DRIVEN TO BEDROCK EXCEPT AT W. PIER. PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD SS 3-11 USING DESIGN LOAD 165 TONS/PILE BUT MUST BE DRIVEN BELOW EL. 1300.00.
 - TUBE PILES TO BE DRIVEN TO EL. SHOWN.
 - PILE SPACING TO BE MEASURED AT UNDERSIDE OF FOOTING.
 - REINFORCING STEEL IN EAST ABUTMENT FOOTING SIMILAR TO WEST ABUTMENT FOOTING.
 - STEEL TUBES SHALL CONFORM TO A.S.T.M. SPECIFICATION A252 GRADE 2, AND HOLLOW STRUCTURAL SECTION C.S.A. G40.21-GRADE 42 W AND TO BE PAINTED ABOVE GROUND LINE.
 - TEMPORARY BRACING FOR PIER BENTS TO BE PROVIDED DURING CONSTRUCTION.
 - PILE LENGTH SHOWN ON THE DRAWING IS THE THEORETICAL LENGTH BELOW CUT-OFF.

STEEL TUBES				
LOCATION	TYPE	Nº REQ'D.	TUBE LENGTH	REMARK
E. PIER	24" O.D. 1/2" WALL THICKNESS	2	STRAIGHT 15'-0"	FILL WITH CONCRETE 3000 P.S.I.
W. PIER		2	1:6 BATTER 15'-6"	
		2	STRAIGHT 23'-0"	
		2	1:6 BATTER 23'-6"	

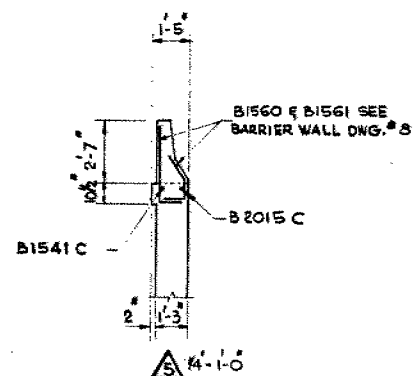
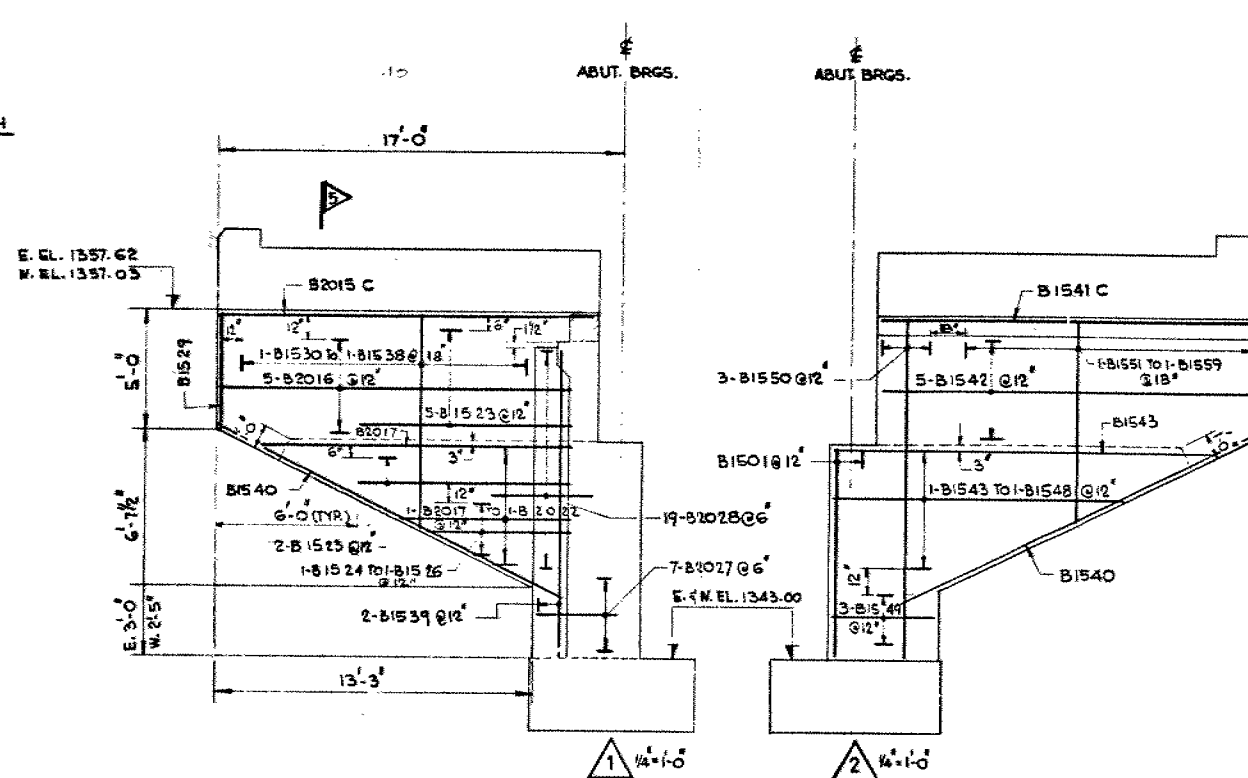
CONCRETE IN STEEL TUBE PILES - 11.6 CU.YD.
TREMIE CONC. IN STEEL TUBE PILES - 4.5 CU.YD.



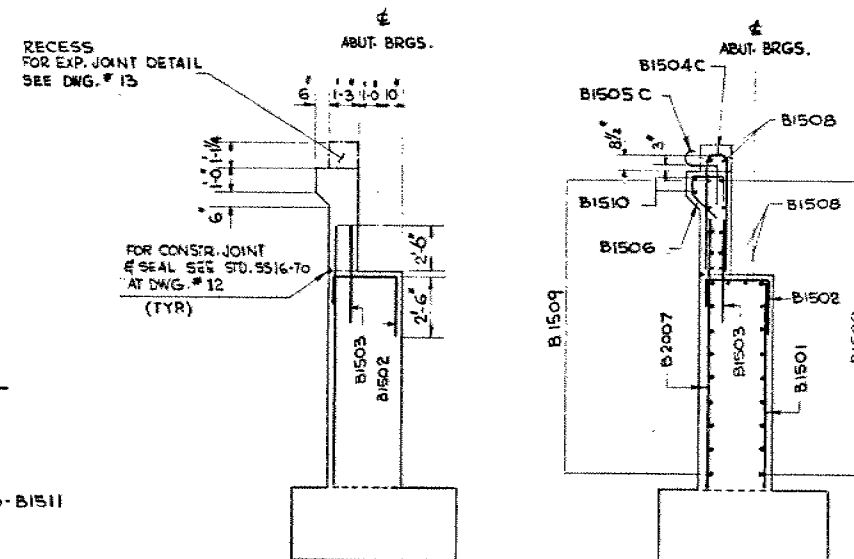
NOTE: PLATE TO BE BURNED WITH A TOLERANCE OF $\pm 1/8"$ TO FIT HP 12 x 117 STEEL 'H' PILES BEFORE DRIVING THE TUBE PILES.



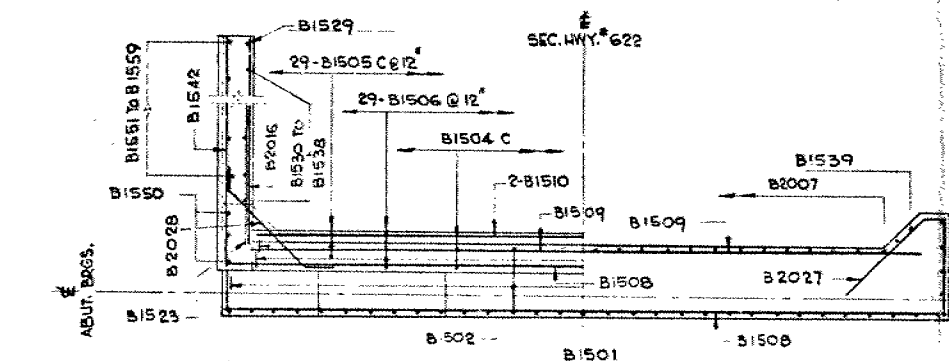
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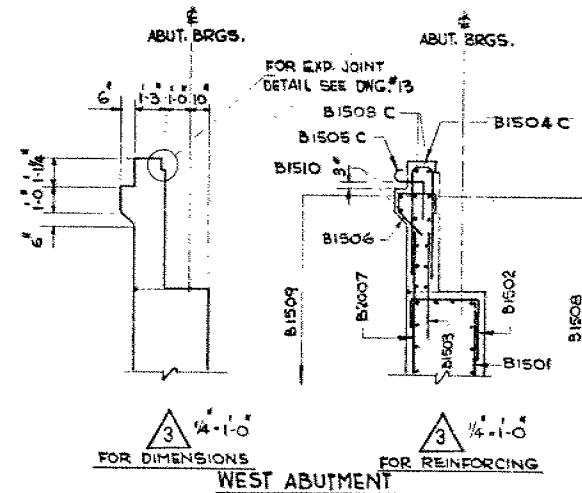
NOTE:
EAST ABUTMENT SHOWN
WEST ABUTMENT SIMILAR EXCEPT AS NOTED



NOTE:
TOP OF BALLAST WALL TO BE CAST
TO SUIT PAVEMENT PROFILE.


$$\Delta \quad \frac{1}{2} \frac{d^2}{dt^2} = 0$$

EAST ABUTMENT



 $\frac{1}{4} \times 1'-0"$  $\frac{1}{4} \times 1'-0"$
 FOR DIMENSIONS FOR REINFORCING
 WEST ABUTMENT



REVISIONS					
	DATE	BY	DESCRIPTION		
DESIGN	✓	CHECK	✓	LOADINGS 26-4	DATE 1/27
DRAWING	✓	CHECK	✓	SITE No 45-128	DWG 4

ENGINEERING MATERIALS OFFICE
SOIL MECHANICS SECTION

WP 18-77-07

DIST 19

HWY Acc. Rd. STR SITE N/A

Bending Lake Road and
Seine River Diversion Structure

DISTRIBUTION

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SAMPLE DISPOSITION NOTICE		
TYPE	DISCARD AFTER	RECOMM. BY
JARS	79-02-01	148
TUBES	"	"
ROCK CORES	"	"

FOUNDATION INVESTIGATION REPORT

For

Bending Lake Road and
Seine River Diversion Structure
7.0 Miles North of Secondary Hwy. 622
District 19, Thunder Bay
Access Road, W.P. 18-77-07

INTRODUCTION

This report contains the results of our foundation investigation at the above mentioned site. The fieldwork was carried out during the period of October 26, 1978 to November 8, 1978. Two types of equipment were utilized for the field investigation.

- a) continuous flight auger machine mounted on a muskeg vehicle and equipped with 3½" I.D. hollow stem augers for boreholes located on land
- b) boreholes located in the river were drilled with conventional diamond drilling equipment (raft mounted) adapted for soil sampling purposes using NX (3 inch I.D.) and BX (2 3/8 inch I.D.) casings.

SITE DESCRIPTION

The site is located at the crossing of the realigned Bending Lake Road and Seine River Diversion, some 7.0 miles north of Secondary Hwy. 622. The surrounding terrain is hilly and bush covered. Rock outcrops are visible south of the site. The width of river along the proposed alignment is about 470 feet and the maximum water depth encountered is 10 feet.

SUBSURFACE CONDITIONS

The subsoil at this site, in general, was found to consist of about four different types of deposits: clayey silt, silt, glacial till and bedrock. In Borehole #4, the silt and glacial till type deposits have been replaced by a bouldery sand and gravel stratum. In Borehole #7 the clayey silt is overlain by a silty sand zone.

Reference should be made to the Record of Borehole Sheets which are contained in the Appendix of this report. These sheets contain the extent and the descriptions of the soil and bedrock types encountered and also, in summarized form, the results of all field and laboratory tests performed.

The stratigraphical profile shown on Drawing No. 187707-A is based on this information. This drawing also shows the locations and elevations of the borings. Detailed description of the various strata are given below.

Silty Sand With Gravel and Traces of Clay

In Borehole #7 which is located on land west of the river, a granular type deposit was encountered below the topsoil for a distance of about 14 feet. The material in the deposit consists of gravel (31%), sand (33%), silt (32%) and clay (4%). The denseness may be described as very loose.

Clayey Silt

This deposit was encountered at every boring location and extends from the ground level or from the above described silty sand zone to a maximum depth of 28 feet (B.H. #6). In boreholes No. 8 and 2, the thickness is only about 8 feet. The lower boundary was found to vary between elevation 1318 and elevation 1331.

The material in the deposit consists mainly of clayey silt with some sand. Irregular layers of clayey silt to silt and seams of sandy silt were also encountered. This clayey silt is inorganic and has a low plasticity. A plot of plasticity index versus liquid limit shows that most of the points fall within the CL zone (Figure 1).

Physical properties of the material as determined from field and laboratory tests are summarized as follows:

		<u>Range</u>
Natural Moisture Content	(%)	28- 75
Liquid Limit	(%)	22- 33
Plastic Limit	(%)	15- 23
Bulk Density	(PCF)	106- 103
Undrained Shear Strength	(PSF)	
Unconfined		304- 700
Field Vane		400-1280
Sensitivity		2- 5

Grain size distribution curves are presented in an envelope form on Figure 2.

The consistency of the overall deposit may be described as very soft to stiff. For design purposes an undrained shear strength value (C_u) of 500 psf is recommended.

Consolidation tests which were carried out on samples indicate the stratum to be overconsolidated by about 1.5 tsf. These tests are plotted on Figure 3 in the Appendix.

Silt

Below the clayey silt stratum a deposit of silt was found in all but #4 and #6 boreholes. At boring locations where this deposit was fully penetrated, the thickness varied from 9 feet to 22 feet. The material is composed of silt, traces of gravel, sand and clay. The natural moisture content is in the order of 28%. The results of the grain size distribution tests are plotted on Figure 4 of the Appendix.

Standard Penetration Tests 'N' values ranged from 6 to 28 blows per foot indicating that the denseness varies from loose to compact.

Glacial Till (Heterogeneous Mixture of Gravel, Sand, Silt and Clay)

Immediately beneath the silt deposit a glacial till stratum was encountered in Boreholes #1, #2, #3, #5 and #6. At other boring locations the drilling was terminated in the silt (B.H. #7 & 8)

or sand and gravel with boulder zones. The maximum thickness observed is about 27 feet. The upper boundary was found to vary between elevation 1298+ and elevation 1313+. This glacial stratum is composed of a heterogeneous mixture of gravel, sand, silt and clay. The matrix of this till is basically granular in nature. There are random localized zones within this material; where the matrix is cohesive, i.e. clayey silt binding coarser sized particles. The natural moisture content ranges from 2% to 11%. Grain size distribution tests carried out on samples from the stratum are presented in an envelope form on Figure 5 of the Appendix.

Standard Penetration Tests carried out within the deposit gave 'N' values ranging from 14 blows per foot to 50 blows per 2 inches. In general, the 'N' values were in excess of 50 blows per foot. Based on these results, it is estimated that the denseness of the stratum varies from compact to very dense.

Sand and Gravel With Boulders

Refusal to conventional washboring techniques was reached in Borehole #4 at elevation 1318+. The borehole was advanced either by drilling with a tri-cone bit or using a BXL core barrel for an approximate distance of 10 feet. Several pinkish coloured rock fragments ranging from 1/4 inch to 7 inches in size, together with sand and gravel, were recovered.

Bedrock

The bedrock at this location as described by Mrs. Z. Koniuszy, Geologist, consists of greenish-grey, medium hard schist. The dip of the bedding planes is near 90°. Occasional vertical joints were also observed in the otherwise sound rock core samples.

Groundwater Conditions

The groundwater level in boreholes located on land was found to be slightly higher (about 10 inches) than the river level. Minor fluctuation, about 2.5 inches, of the Seine River water level was observed during the field investigation.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to build a new three span structure some 80 feet downstream of the existing one. The profile is set at elevation 1364₊ (Sta. 261+00) some 31 feet above the river bottom. At the time of the report writing, the footing locations are not finalized. It is indicated, however, that the new bridge will be designed as a three span (80'-140'-80') structure.

Structure Foundation

The encountered subsurface conditions do not favor spread footing type foundations. Therefore, piled foundations are recommended.

End-Bearing Piles

The abutments and piers of the proposed new structure may be founded on end-bearing steel 'H' piles driven to bedrock. The bedrock was found to be at the following levels:

Sta. 257+98	Elevation 1305 ₊
Sta. 258+97	Elevation 1303 ₊
Sta. 260+05	Elevation 1284 ₊
Sta. 262+03	Elevation 178 ₊

In the vicinity of Sta. 261₊ a very dense zone composed of sand and gravel with boulders was encountered at elevation 1318₊. It is assumed that piles driven at this location will not reach the bedrock surface.

Hard driving is expected within the glacial till and the bouldery sand and gravel deposits, therefore, reinforcement of the pile tips is recommended. For piles driven to refusal or bedrock the maximum allowable design loads for the particular pile section adapted may be assumed.

The pile caps should be protected against frost action with a minimum of 8 feet of earth cover.

Visual inspections have revealed that at certain locations adjacent to the proposed alignment, large boulders are covering the river bed. It is, therefore, recommended that all the boulders (if any) be removed at locations where piles have to be driven.

Approach Embankments

Stability analyses, in terms of total stresses, have been carried out with the following assumptions of soil properties:

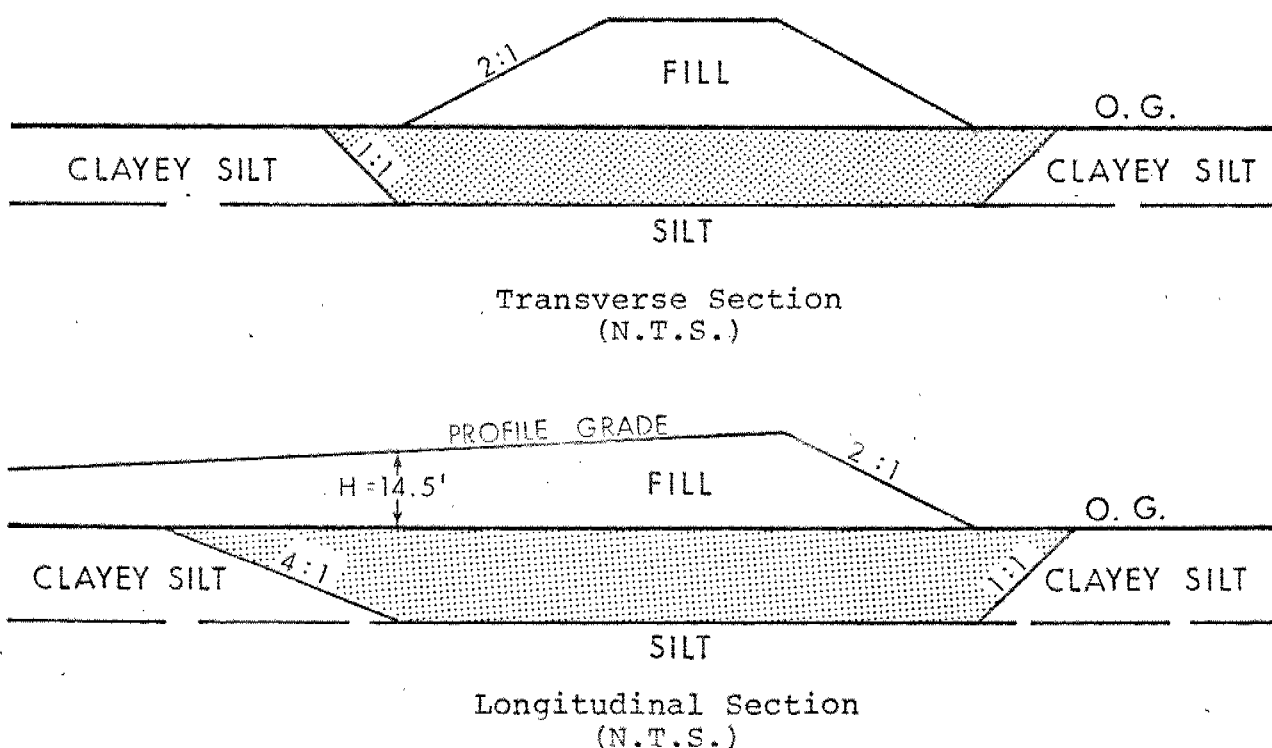
Fill Material $\phi = 27^\circ$
 $= 135 \text{ PCF}$

Subsoil (clayey silt) $c_u = 500 \text{ PSF}$
 $= 108 \text{ PCF}$

The results of these stability computations indicated that the maximum safe embankment height under these conditions is about 14.5 feet. Consequently, where proposed heights exceed this figure, special measures have to be carried out to ensure the stability of the approaches against failure. This can be achieved by one of the following methods.

a) Subexcavation

All the soft to firm clayey silt material (see Drawing 187707-A) should be removed as indicated on the following sketch:



The limits of the subexcavation are indicated on these sketches by the shaded areas. The removed material should be replaced with noncohesive material. The remaining of the embankments can be built by using well compacted acceptable material. No bouldery fill should be used at locations where piles have to be driven. The maximum grain size should not exceed 3 inches. This rule also applies to the subexcavated portion.

b) Grade-Line Lowering

Consideration should be given to lowering the proposed profile grade to a level where the height of the embankment will not exceed 14.5 feet above the original ground level at the toe of the slope.

c) Berms

The stability of the embankment can also be ensured by the construction of balancing berms, but will require a longer structure. The cost of a longer structure and building of berms will be over the cost of subexcavation. In our opinion, the subexcavation is a better method to overcome the stability problems.

The river bed and the approach embankments should be protected against scour and erosion according to the recommendations of the Hydrology Section.

Settlements of about 6 inches to 8 inches are expected below an 15 foot high embankment.

MISCELLANEOUS

The supervision of the fieldwork and the preparation of this report was carried out by P. Payer, Senior Engineer. Mr. K.G. Selby, Supervising Engineer, reviewed this report.

for B. L. y

P. Payer, P. Eng.
Senior Engineer

K. G. Selby

K.G. Selby, P. Eng.
Supervising Engineer



January, 1979

APPENDIX



RECORD OF BOREHOLE No 1

W.P. 18-77-07 LOCATION Sta. 263+06, o/s 10' Rt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Washbore, BX and NX Casing and Cone Test COMPILED BY P.P.
DATUM Geodetic DATE October 26-27, 1978 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
1339.9	Water Level													
0.0	River Bottom													
1.2	Clayey Silt Layers of Sandy Silt Soft to Stiff		1	SS	PM									0 10 61 29
			2	SS	2									
			3	SS	4		1330							0 20 69 11
			4	TW	PM								108	0 6 66 28
			5	SS	1		1320							0 12 73 15
1318.0	Silt Traces of Sand and Clay Compact		6	SS	28									
			7	SS	26		1310							
			8	SS	12									0 6 89 5
1302.9	Heterogeneous Mixture of Gravel, Sand, Silt and Clay, Compact Glacial Till		9	SS	14		1300							16 16 62 6
1296.3	End of Borehole													
43.6	End of Cone Test													
1293.0														
46.9														



RECORD OF BOREHOLE No 2

W P 18-77-07 LOCATION Sta. 258+97: o/s 5' Lt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Washbore NX Casing, BXL Rock Coring COMPILED BY P.P.
DATUM Geodetic DATE October 27-31, 1978 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1339.9	Water Level																
0.0	Water																
1336.5	River Bottom																
3.4	Clayey Silt to Silt, Some Sand		1	SS	1/20												1 7 56 36
1328.9	Very Soft		2	TW	PM		1330										
11.0	Silt Traces of Sand and Clay		3	SS	11												0 5 89 6
	Compact		4	SS	10		1320										
	Grey		5	SS	12												
1311.5																	
28.4	Heterogeneous Mixture of Gravel, Sand, Silt and Clay, Dense to Very Dense		6	SS	40		1310										9 12 75 4
1302.8	Glacial Till		7	SS	134												
37.1	Bedrock Schist Sound		8	RC	100		1300										
			9	RC BXL	100%												
1293.4			10	RC BXL	100%												
46.5	End of Borehole																



RECORD OF BOREHOLE No 3

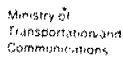
W P 18-77-07 LOCATION Sta. 260+05; o/s 3' Rt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Washbore-BX Casing-BXL Rock Coring COMPILED BY P.P.
DATUM Geodetic DATE November 1-2, 1978 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1339.9	Water Level																
0.0	Water																
1337.5	River Bottom																
2.4	Clayey Silt Traces of Sand Very Soft to Firm		1	SS	2		1330										0 2 57 41
1322.1																	
17.8	Silt Traces of Sand and Clay Loose		2	SS	6		1320										
1313.1																	
26.8	Heterogeneous Mixture of Gravel, Sand, Silt and Clay Dense to Very Dense		3	SS	33		1310										23 58 17 2
	Glacial Till		4	SS	95		1300										
			5	SS	63		1290										0 91 (9)
1283.9																	
56.0	Bedrock		6	RC	Rec												
1280.1	Sound Schist			BXL	90%												
59.8	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

W P 18-77-07 LOCATION Sta. 261+00; o/s 4' Rt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Washbore-BX Casing COMPILED BY P.P.
DATUM Geodetic DATE November 3, 1978 CHECKED BY RS

[illegible]

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 5

W P 18-77-07 LOCATION Sta. 262+03; o/s 4' Lt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Washbore-NX Casing and Cone Test COMPILED BY P.P.
DATUM Geodetic DATE November 6-8, 1978 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1339.9	Water Level																
0.0	Water																
1330.3	River Bottom																
9.6	Clayey Silt Traces of Sand		1	TW	PM		1330		+3								0 6 62 32
			2	TW	PM				+3								0 5 67 28
1319.9	Soft to Firm		3	TW	PM		1320			+3							
20.0	Silt Some Clay Traces of Gravel and Sand Loose to Compact		3A	SS	-												1 1 86 12
			4	SS	6												
			5	SS	24		1310										
			5A	SS	25												
			6	SS	18		1300										
1298.1	Heterogeneous Mixture of Gravel, Sand, Silt and Clay Occasional Boulders Compact to Very Dense Glacial Till		7	SS	24		1290										23 55 17 5
			8	SS	33												
			9	SS	50/2"												
			10	SS	129/7.5"		1280										
1278.0	Refusal End of Borehole Probable Bedrock																
61.9																	



RECORD OF BOREHOLE No 6

W P 18-77-07 LOCATION Sta. 257+98; o/s 1' Lt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Continuous Flight Auger - BX Rock Coring COMPILED BY P.P.
DATUM Geodetic DATE November 7-8, 1978 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1351.7	Ground Level																
0.0	Topsoil																
	Clayey Silt		1	SS	2		1350										
	Traces of Sand		2	SS	5		1340										
	Occasional Silt Layers		3	SS	5		1330										0 4 72 24
	Soft to Firm		4	SS	5		1320										0 1 89 10
1323.7			5	SS	4		1310										
28.0	Heterogeneous Mixture of Gravel, Sand and Silt		6	SS	47		1300										27 49 21 3
	Very Dense		7	SS	95												
	Glacial Till		8	SS	136												25 64 (11)
1304.7			9	SS	125												
47.0	Boulders		10	RC BX	Rec 32%												
	Bedrock Schist		11	RC BX	Rec 100%												
	Sound		12	RC BX	Rec 95%												
1293.2																	
58.5	End of Borehole																

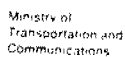
OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 7

W P 18-77-07 LOCATION Sta. 263+89; 9/s 2' Lt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Continuous Flight Auger and Cone Test COMPILED BY P.P.
DATUM Geodetic DATE November 8, 1978 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	1					
1345.5	Ground Level													
0.0	Topsoil (Org.) Silty Sand With Gravel Traces of Clay Very Loose		1	SS	1		1340							31 33 32 4
1331.5			2	SS	2									
14.0	Clayey Silt to Silt (Layered) Some Sand Soft to Firm		3	SS	3		1330	+ 5						0 19 67 14
			4	SS	1			+ 4						0 10 61 29
1318.5			5	TW	PM		1320							0 12 75 13
27.0	Silt													
1314.0	Compact		6	SS	17									
31.5	End of Borehole						1310							
							1300							
1291.6														
53.9	End of Cone Test													



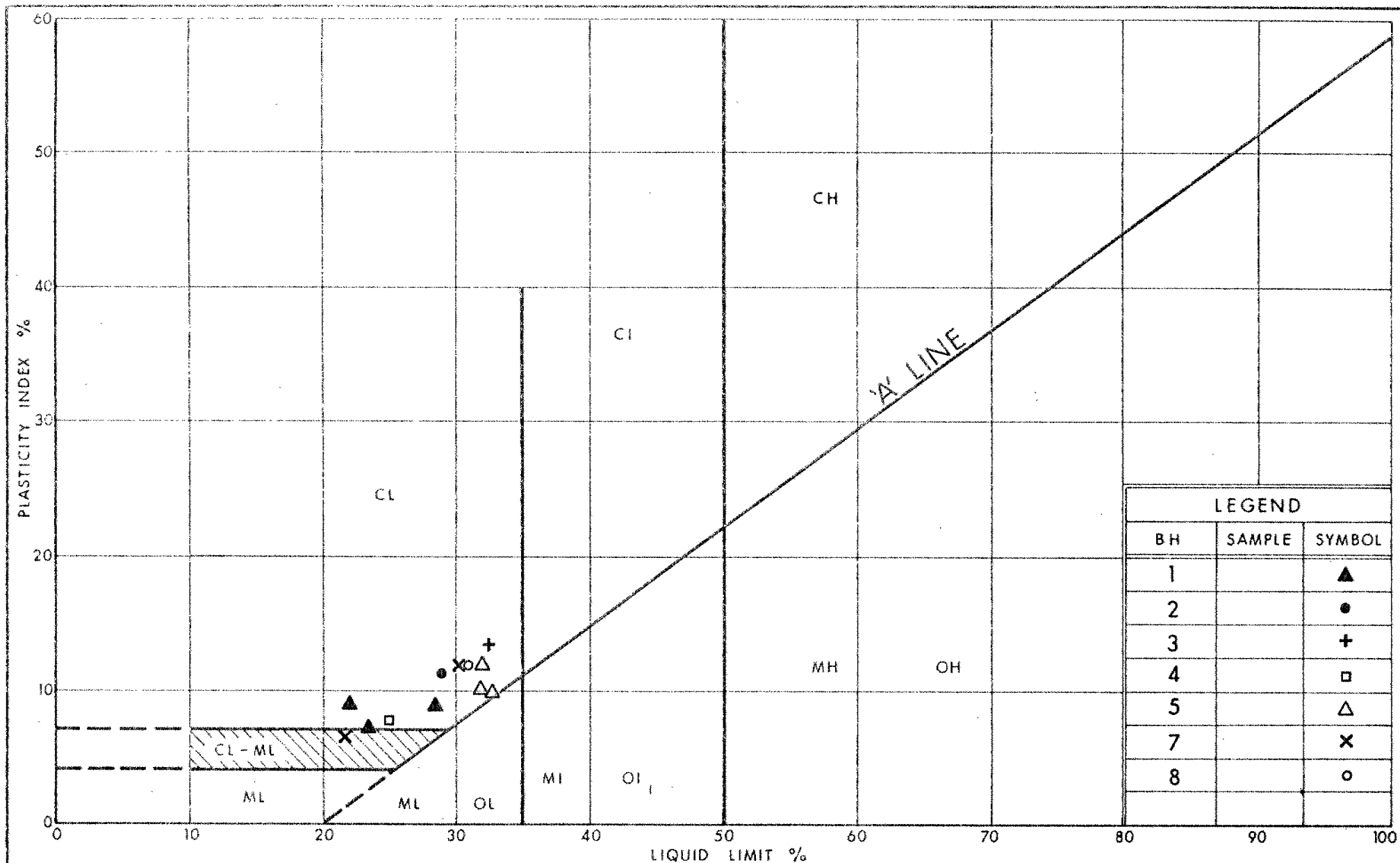
RECORD OF BOREHOLE No 8

W P 18-77-07 LOCATION Sta. 262+10, o/s 55' Lt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Local BOREHOLE TYPE Washboring NX Casing and Cone Test COMPILED BY R.S.
DATUM Geodetic DATE November 9, 1978 CHECKED BY RS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES		20 40 60 80 100			
1339.9	Water Level											
0.0	Water											
1331.8	River Bottom											
8.1	Clayey Silt Trace of Sand Very Soft to Firm		1	SS	1/24"	1330	+2				74%	0 9 61 30
1322.9	Silt, Some Sand, Trace of Clay, Compact		2	SS	PM		+2				106	0 12 80 8
17.0	End of Borehole		3	SS	10'	1320						
1319.3												
20.6												
1300.4												
39.5	End of Cone Test						106/5"					

+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



Ontario

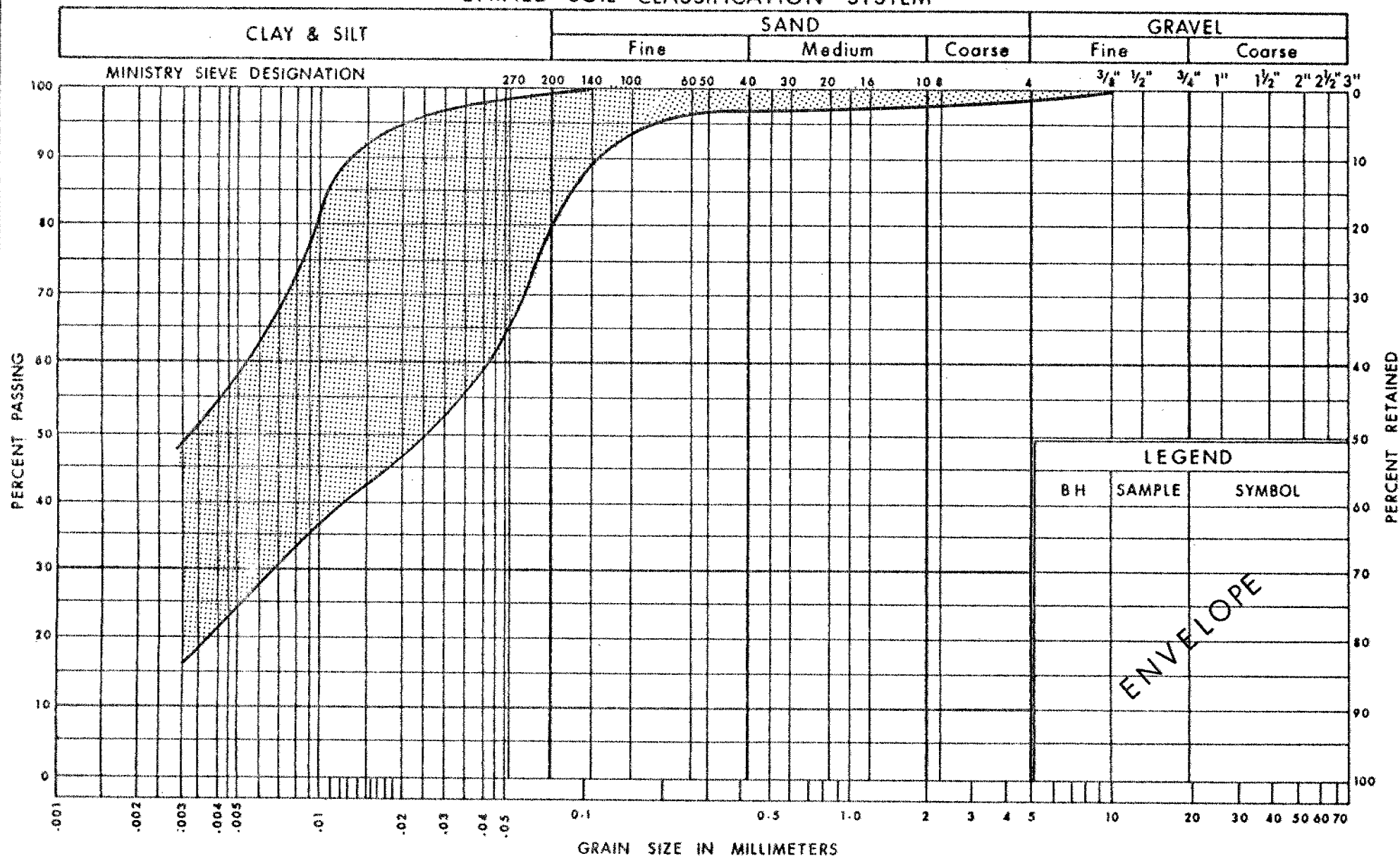
 Ministry of
Transportation and
Communications

 PLASTICITY CHART
CLAYEY SILT (LAYERED)
SOME SAND

FIG No 1

W P 18 - 77 - 07

UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
CLAYEY SILT
TRACES OF SAND

FIG No 2

W P 18-77-07

VOID RATIO-PRESSURE CURVES

WP. 18 - 77 - 07

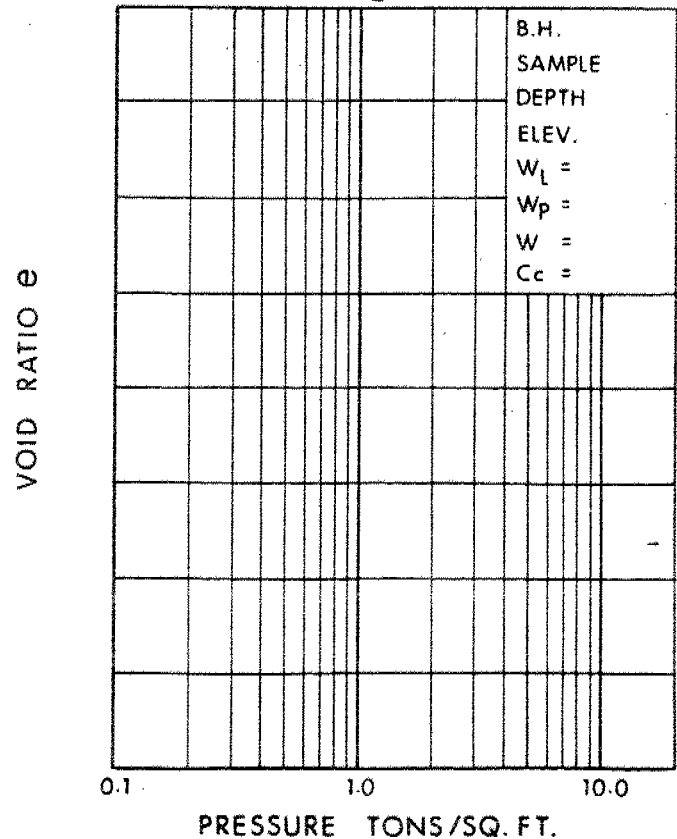
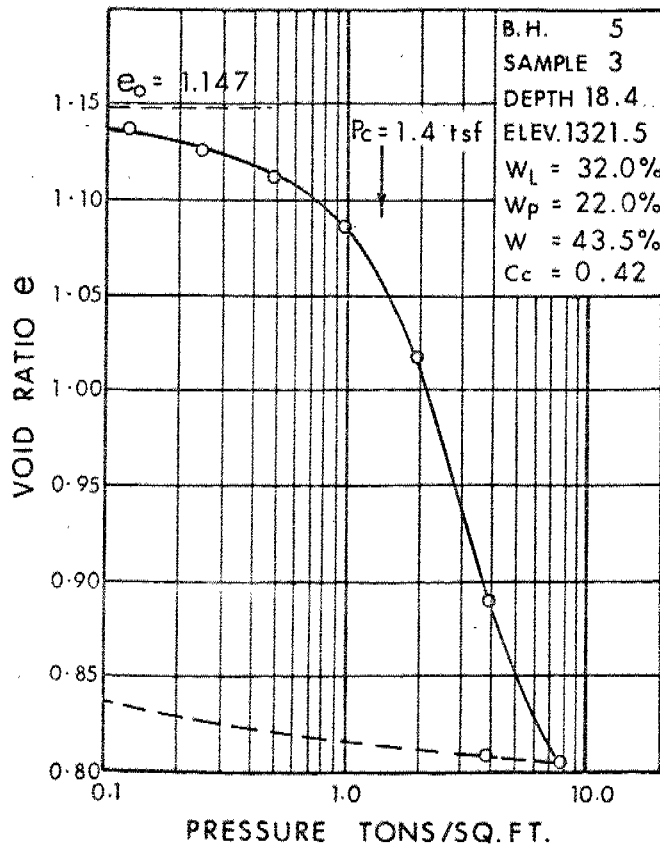
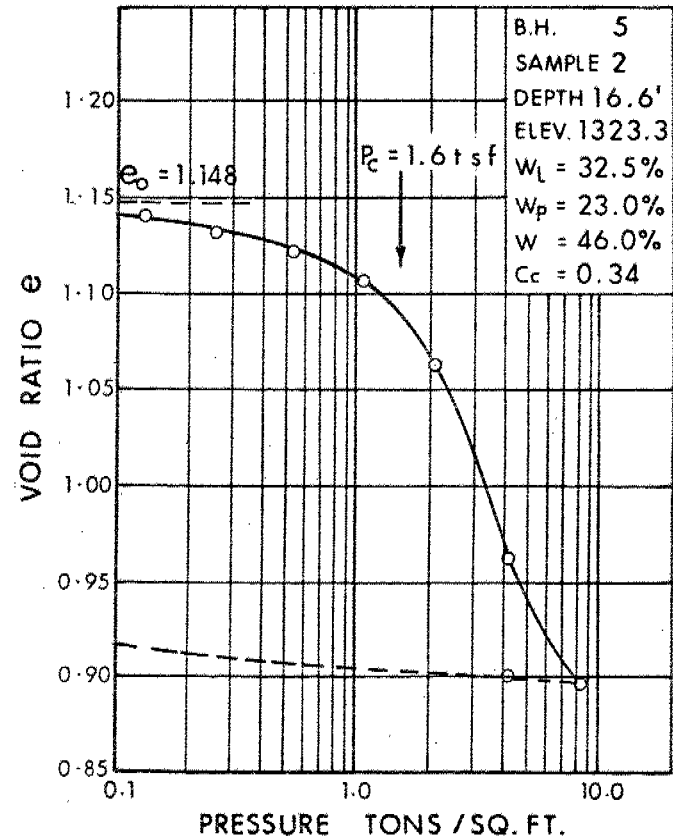
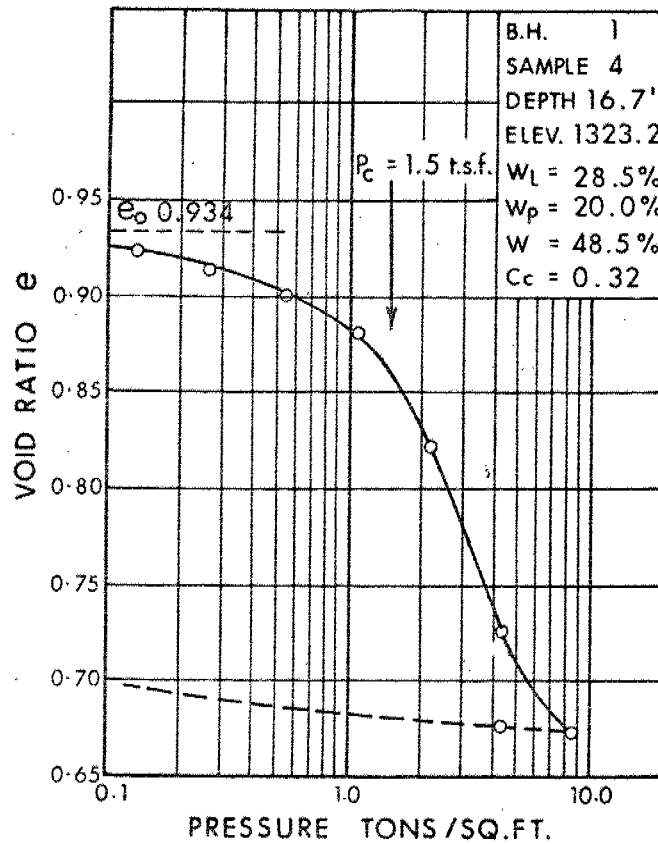
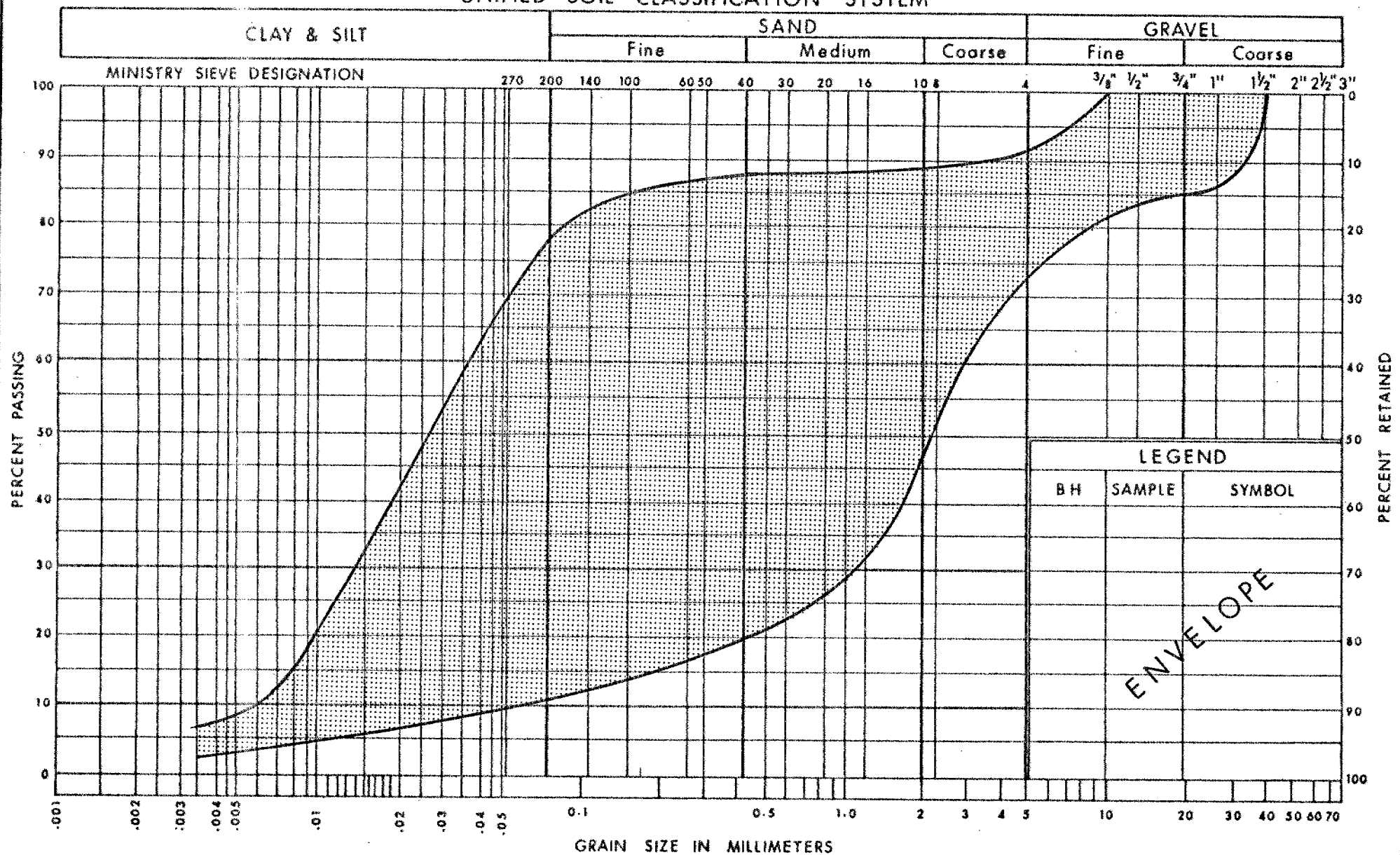


FIG. 3



GRAIN SIZE DISTRIBUTION
SILT
TRACES OF GRAVEL, SAND & CLAY

WP 18 - 77 - 07



Ontario

Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION GLACIAL TILL

HET MIX OF GRAVEL, SAND, SILT & CLAY

FIG No 5

W P 18-77-07

EXPLANATION OF TERMS USED IN REPORT

'N' VALUE: AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS N_c .

DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON 1/2" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOIL QUALITY: SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNKNAINED SHEAR STRENGTH AS FOLLOWS:

S_u (FSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCK QUALITY: ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS & SYMBOLS

LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG. CTU = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

FIELD SAMPLING

S S SPLIT SPOON
W S WASH SAMPLE
S T SLOTTED TUBE SAMPLE
B S BLOCK SAMPLE
C S CHUNK SAMPLE
T W THINWALL OPEN
T P THINWALL PISTON
O S OSTERBERG SAMPLE
F S FOIL SAMPLE
R C ROCK CORE
P H T.W. ADVANCED HYDRAULICALLY
P M T.W. ADVANCED MANUALLY

EARTH PRESSURE TERMS

μ COEFFICIENT OF FRICTION
 δ ANGLE OF WALL FRICTION
 σ_o COEFFICIENT OF EARTH PRESSURE AT REST
 σ_a COEFFICIENT OF ACTIVE EARTH PRESSURE
 σ_p COEFFICIENT OF PASSIVE EARTH PRESSURE
 α ANGLE OF INCLINATION OF SURCHARGE
 θ SLOPE ANGLE-BACKFACE OF WALL
 β ANGLE OF SLOPE
 γ_{sat} BRANING CAPACITY FACTOR
 D_f DEPTH OF FOOTING
 B, L FOOTING DIMENSIONS

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
 γ' UNIT WEIGHT OF SUBMERGED SOIL
 G_s SPECIFIC GRAVITY OF SOLIDS
 e VOIDS RATIO
 e_o INITIAL VOIDS RATIO
 e_{max} e IN LOOSEST STATE
 e_{min} e IN DENSEST STATE
 D_r RELATIVE DENSITY = $\frac{e_{max} - e}{e_{max} - e_{min}}$
 n POROSITY
 w WATER CONTENT
 w_L LIQUID LIMIT
 w_p PLASTIC LIMIT
 w_s SHRINKAGE LIMIT
 I_p PLASTICITY INDEX = $w_L - w_p$
 I_L LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
 I_c CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
 A_c ACTIVITY = $\frac{I_p \text{ at } 25^\circ C}{I_p \text{ at } 70^\circ C}$
 O_m ORGANIC MATTER CONTENT
 S_r DEGREE OF SATURATION
 S SENSITIVITY = $\frac{S_u (\text{undisturbed})}{S_u (\text{remoulded})}$

STRENGTH PARAMETERS

ϕ ANGLE OF SHEARING RESISTANCE
 τ_t PEAK SHEAR STRENGTH
 τ_R RESIDUAL SHEAR STRENGTH
 c COHESION INTERCEPT
 $\sigma_1, \sigma_2, \sigma_3$ NORMAL PRINCIPAL STRESSES
 u PORE WATER PRESSURE
 u_v EXCESS u
 r_u PORE PRESSURE RATIO
 σ_{cu} UNCONFINED COMPRESSIVE STRENGTH
 s_u UNDRAINED SHEAR STRENGTH
 ϵ LINEAR STRAIN
 γ SHEAR STRAIN
 ν POISSON'S RATIO
 E MODULUS OF ELASTICITY
 G MODULUS OF SHEAR DEFORMATION
 K_s MODULUS OF SUBGRADE REACTION
 ϕ, δ STABILITY COEFFICIENTS
 A, B PORE PRESSURE COEFFICIENTS

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHES ABOVE THE SYMBOL, THUS:
 σ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE;
 σ'_n = EFFECTIVE NORMAL STRESS

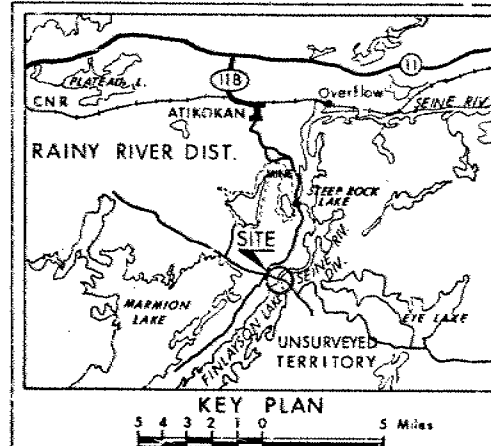
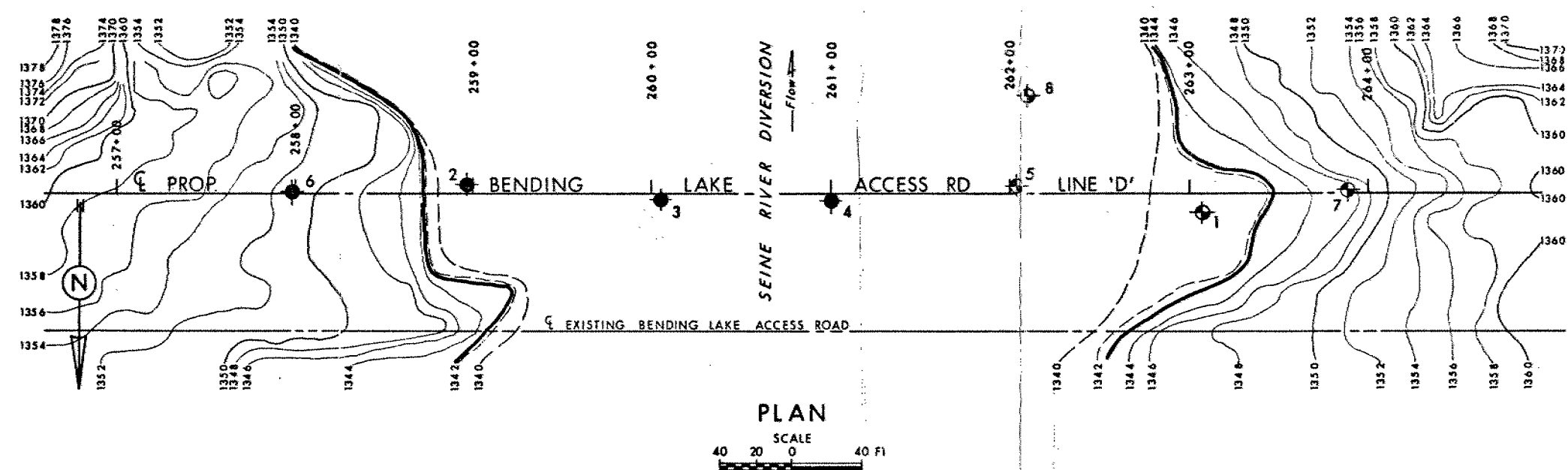
HYDRAULIC TERMS

h HYDRAULIC HEAD OR POTENTIAL
 θ PAIR OF DISCHARGE
 v VELOCITY OF FLOW
 J -HYDRAULIC GRADIENT
 i SEEPAGE FORCE PER UNIT VOLUME
 η COEFFICIENT OF VISCOSITY
 k COEFFICIENT OF UTHERLAND CONDUCTIVITY
 k_h k IN HORIZONTAL DIRECTION
 k_v k IN VERTICAL DIRECTION
 α_v COEFFICIENT OF VOLUME CHANGE
 α_s COEFFICIENT OF COMPRESSION
 C_c COMPRESSION INDEX
 C_r RECOMPRESSION INDEX
 L SEEPAGE PATH DISTANCE
 T_v TIME FACTOR
 U DEGREE OF CONSOLIDATION
 U_{cr} OVERCONSOLIDATION RATIO (OCR)

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO
08-MT-508 10-76

CONT No
WP No 18-77-07

BENDING LAKE RD. & SEINE RIV. DIV.
(7.0 Miles North of Sec Hwy 622)
BORE HOLE LOCATIONS & SOIL STRATA



- LEGEND**
- Bore Hole
 - ⊕ Dynamic Cone Penetration Test (Cone)
 - ⊙ Bore Hole & Cone
 - 'N' Blows/ft (Std Pen Test 350 ft lbs energy)
 - CONE Blows/ft (60° Cone, 350 ft lbs energy)
 - ↓ WL at time of investigation Oct 1978

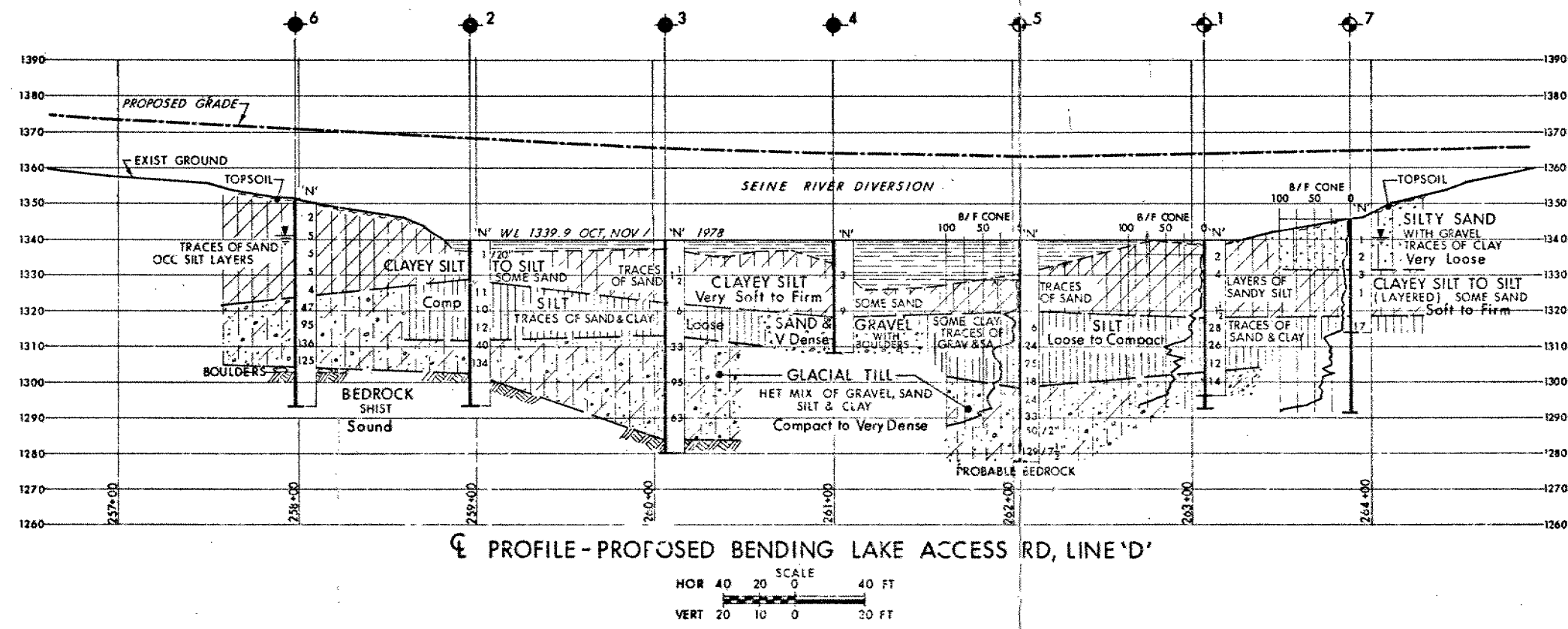
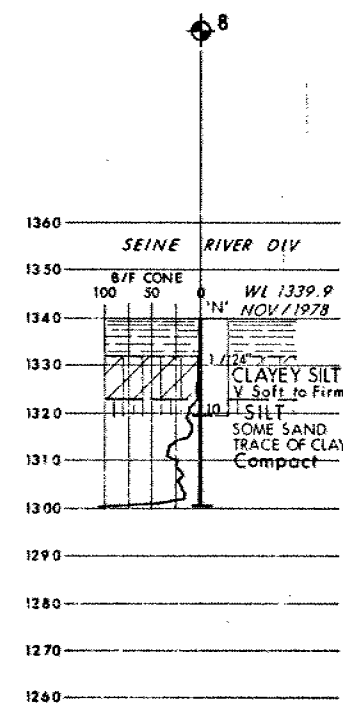
No	ELEVATION	STATION	OFFSET LINE 'D'
1	1339.9	263+06	10' RT
2	1339.9	258+97	5' LT
3	1339.9	260+05	3' RT
4	1339.9	261+00	4' RT
5	1339.9	262+03	4' LT
6	1351.7	257+98	1' LT
7	1343.5	263+89	2' LT
8	1339.9	262+10	55' LT

-NOTE-
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

GEOCRE No 528-6

FILE No BENDING LAKE RD. SITE 19
SUBMIT. P.P. CHECKED DATE Jan 10, 1979 SITE
DRAWN BY S. H. CHECKED BY A. H. H. 187707-A



PROFILE - PROPOSED BENDING LAKE ACCESS RD, LINE 'D'

Index

<u>Page No.</u>	<u>Description</u>
1	Index
2	Abbreviations & Symbols
3- 19	Foundation Investigation Report Bending Lake Rd. and Seine River Diversion Structure, W.P. 18-77-07.

NOTE: For purposes of the Contract this report supercedes all other foundation reports done by or for the Ministry in connection with the above mentioned project.

EXPLANATION OF TERMS USED IN REPORT

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SOIL QUALITY: SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH AS FOLLOWS:

S _u (PSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCK QUALITY: ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

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RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS & SYMBOLS

LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG. CIU = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

FIELD SAMPLING

SS SPLIT SPOON
WS WASH SAMPLE
ST SLOTTED TUBE SAMPLE
BS BLOCK SAMPLE
CS CHUNK SAMPLE
TW THINWALL OPEN
TP THINWALL PISTON
OS OSTERBERG SAMPLE
FS FOIL SAMPLE
RC ROCK CORE
PH T.W. ADVANCED HYDRAULICALLY
PM T.W. ADVANCED MANUALLY

EARTH PRESSURE TERMS

μ COEFFICIENT OF FRICTION
 δ ANGLE OF WALL FRICTION
 k_o COEFFICIENT OF EARTH PRESSURE AT REST
 k_A COEFFICIENT OF ACTIVE EARTH PRESSURE
 k_P COEFFICIENT OF PASSIVE EARTH PRESSURE
 i ANGLE OF INCLINATION OF SURFACE
 α SLOPE ANGLE-BACKFACE OF WALL
 β ANGLE OF SLOPE
 N, N_q, N_c BEARING CAPACITY FACTORS
 D_f DEPTH OF FOOTING
 B, L FOOTING DIMENSIONS

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
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 G_s SPECIFIC GRAVITY OF SOLIDS
 e VOIDS RATIO
 e_o INITIAL VOIDS RATIO
 e_{max} " IN LOOSEST STATE
 e_{min} " IN DENSEST STATE
 D_r RELATIVE DENSITY = $\frac{e_{max} - e}{e_{max} - e_{min}}$
 n POROSITY
 w WATER CONTENT
 w_L LIQUID LIMIT
 w_p PLASTIC LIMIT
 w_s SHRINKAGE LIMIT
 I_p PLASTICITY INDEX = $w_L - w_p$
 I_L LIQUIDITY INDEX = $\frac{w - w_p}{w_L - w_p}$
 I_c CONSISTENCY INDEX = $\frac{w_L - w}{w_L - w_p}$
 A_c ACTIVITY = $\frac{I_p \text{ of soil}}{I_p \text{ of } 2\mu m \text{ Soil Fraction}}$
 O_m ORGANIC MATTER CONTENT
 S_r DEGREE OF SATURATION
 S SENSITIVITY = $\frac{S_u \text{ (undisturbed)}}{c \text{ (remoulded)}}$

STRENGTH PARAMETERS

ϕ ANGLE OF SHEARING RESISTANCE
 τ_f PEAK SHEAR STRENGTH
 τ_R RESIDUAL SHEAR STRENGTH
 c COHESION INTERCEPT
 $\sigma_1, \sigma_2, \sigma_3$ NORMAL PRINCIPAL STRESSES
 u PORE WATER PRESSURE
 u_e EXCESS u
 r_u PORE PRESSURE RATIO
 q_u UNCONFINED COMPRESSIVE STRENGTH
 s_u UNDRAINED SHEAR STRENGTH
 ϵ LINEAR STRAIN
 γ SHEAR STRAIN
 ν POISSON'S RATIO
 E MODULUS OF ELASTICITY
 G MODULUS OF SHEAR DEFORMATION
 k_s MODULUS OF SUBGRADE REACTION
 m, n STABILITY COEFFICIENTS
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 σ' = EFFECTIVE NORMAL STRESS

HYDRAULIC TERMS

h HYDRAULIC HEAD OR POTENTIAL
 q RATE OF DISCHARGE
 v VELOCITY OF FLOW
 i HYDRAULIC GRADIENT
 j SEEPAGE FORCE PER UNIT VOLUME
 η COEFFICIENT OF VISCOSITY
 k COEFFICIENT OF HYDRAULIC CONDUCTIVITY
 k_h k IN HORIZONTAL DIRECTION
 k_v k IN VERTICAL DIRECTION
 ϵ_v COEFFICIENT OF VOLUME CHANGE
 c_v COEFFICIENT OF CONSOLIDATION
 C_c COMPRESSION INDEX
 C_r RECOMPRESSION INDEX
 d DRAINAGE PATH DISTANCE
 T_v TIME FACTOR
 U DEGREE OF CONSOLIDATION
 O_r OVERCONSOLIDATION RATIO (OCR)

FOUNDATION INVESTIGATION REPORT

For

Bending Lake Road and
Seine River Diversion Structure
7.0 Miles North of Secondary Hwy. 622
District 19, Thunder Bay
Access Road, W.P. 18-77-07

INTRODUCTION

This report contains the results of our foundation investigation at the above mentioned site. The fieldwork was carried out during the period of October 26, 1978 to November 8, 1978. Two types of equipment were utilized for the field investigation.

- a) continuous flight auger machine mounted on a muskeg vehicle and equipped with 3½" I.D. hollow stem augers for boreholes located on land
- b) boreholes located in the river were drilled with conventional diamond drilling equipment (raft mounted) adapted for soil sampling purposes using NX (3 inch I.D.) and BX (2 3/8 inch I.D.) casings.

SITE DESCRIPTION

The site is located at the crossing of the realigned Bending Lake Road and Seine River Diversion, some 7.0 miles north of Secondary Hwy. 622. The surrounding terrain is hilly and bush covered. Rock outcrops are visible south of the site. The width of river along the proposed alignment is about 470 feet and the maximum water depth encountered is 10 feet.

SUBSURFACE CONDITIONS

The subsoil at this site, in general, was found to consist of about four different types of deposits: clayey silt, silt, glacial till and bedrock. In Borehole #4, the silt and glacial till type deposits have been replaced by a bouldery sand and gravel stratum. In Borehole #7 the clayey silt is overlain by a silty sand zone.

Reference should be made to the Record of Borehole Sheets which are contained in the Appendix of this report. These sheets contain the extent and the descriptions of the soil and bedrock types encountered and also, in summarized form, the results of all field and laboratory tests performed.

The stratigraphical profile shown on Drawing No. 45-129-2 is based on this information. This drawing also shows the locations and elevations of the borings. Detailed description of the various strata are given below.

Silty Sand With Gravel and Traces of Clay

In Borehole #7 which is located on land west of the river, a granular type deposit was encountered below the topsoil for a distance of about 14 feet. The material in the deposit consists of gravel (31%), sand (33%), silt (32%) and clay (4%). The denseness may be described as very loose.

Clayey Silt

This deposit was encountered at every boring location and extends from the ground level or from the above described silty sand zone to a maximum depth of 28 feet (B.H. #6). In boreholes No. 8 and 2, the thickness is only about 8 feet. The lower boundary was found to vary between elevation 1318 and elevation 1331.

The material in the deposit consists mainly of clayey silt with some sand. Irregular layers of clayey silt to silt and seams of sandy silt were also encountered. This clayey silt is inorganic and has a low plasticity. A plot of plasticity index versus liquid limit shows that most of the points fall within the CL zone (Figure 1).

Physical properties of the material as determined from field and laboratory tests are summarized as follows:

		<u>Range</u>
Natural Moisture Content	(%)	28- 75
Liquid Limit	(%)	22- 33
Plastic Limit	(%)	15- 23
Bulk Density	(PCF)	106- 103
Undrained Shear Strength	(PSF)	
Unconfined		304- 700
Field Vane		400-1280
Sensitivity		2- 5

Grain size distribution curves are presented in an envelope form on Figure 2.

The consistency of the overall deposit may be described as very soft to stiff. For design purposes an undrained shear strength value (c_u) of 500 psf is recommended.

Consolidation tests which were carried out on samples indicate the stratum to be overconsolidated by about 1.5 tsf. These tests are plotted on Figure 3 in the Appendix.

Silt

Below the clayey silt stratum a deposit of silt was found in all but #4 and #6 boreholes. At boring locations where this deposit was fully penetrated, the thickness varied from 9 feet to 22 feet. The material is composed of silt, traces of gravel, sand and clay. The natural moisture content is in the order of 28%. The results of the grain size distribution tests are plotted on Figure 4 of the Appendix.

Standard Penetration Tests 'N' values ranged from 6 to 28 blows per foot indicating that the denseness varies from loose to compact.

Glacial Till (Heterogeneous Mixture of Gravel, Sand, Silt and Clay)

Immediately beneath the silt deposit a glacial till stratum was encountered in Boreholes #1, #2, #3, #5 and #6. At other boring locations the drilling was terminated in the silt (B.H. #7 & 8)

or sand and gravel with boulder zones. The maximum thickness observed is about 27 feet. The upper boundary was found to vary between elevation 1298₊ and elevation 1313₊. This glacial stratum is composed of a heterogeneous mixture of gravel, sand, silt and clay. The matrix of this till is basically granular in nature. There are random localized zones within this material; where the matrix is cohesive, i.e. clayey silt binding coarser sized particles. The natural moisture content ranges from 2% to 11%. Grain size distribution tests carried out on samples from the stratum are presented in an envelope form on Figure 5 of the Appendix.

Standard Penetration Tests carried out within the deposit gave 'N' values ranging from 14 blows per foot to 50 blows per 2 inches. In general, the 'N' values were in excess of 50 blows per foot. Based on these results, it is estimated that the denseness of the stratum varies from compact to very dense.

Sand and Gravel With Boulders

Refusal to conventional washboring techniques was reached in Borehole #4 at elevation 1318₊. The borehole was advanced either by drilling with a tri-cone bit or using a BXL core barrel for an approximate distance of 10 feet. Several pinkish coloured rock fragments ranging from 1/4 inch to 7 inches in size, together with sand and gravel, were recovered.

Bedrock

The bedrock at this location as described by Mrs. Z. Koniuszy, Geologist, consists of greenish-grey, medium hard schist. The dip of the bedding planes is near 90°. Occasional vertical joints were also observed in the otherwise sound rock core samples.

Groundwater Conditions

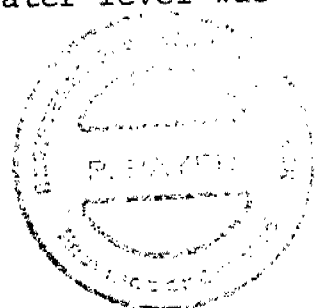
The groundwater level in boreholes located on land was found to be slightly higher (about 10 inches) than the river level. Minor fluctuation, about 2.5 inches, of the Seine River water level was observed during the field investigation.

P. Payer

P. Payer, P. Eng.
Foundations Engineer

K. G. Selby

K.G. Selby, P. Eng.
Senior Foundations Engineer



RECORD OF BOREHOLE No 1

W P 18-77-07 LOCATION Sta. 263+06, o/s 10' Rt. Line 'D' ORIGINATED BY P.P.
 DIST 19 HWY Loc. BOREHOLE TYPE Washbore, BX and NX Casing and Cone Test COMPILED BY P.P.
 DATUM Geodetic DATE October 26-27, 1978 CHECKED BY R.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p W W _L					
1339.9	Water Level													
0.0	River Bottom													
1.2	Clayey Silt Layers of Sandy Silt Soft to Stiff		1	SS	PM									0 10 61 29
			2	SS	2									
			3	SS	4									0 20 69 11
			4	TW	PM								108	0 6 66 28
1318.0			5	SS	1									0 12 73 15
21.9	Silt Traces of Sand and Clay Compact		6	SS	28									
			7	SS	26									
1302.9			8	SS	12									0 6 89 5
37.0	Heterogeneous Mixture of Gravel, Sand, Silt and Clay, Compact		9	SS	14									16 16 62 6
1296.3	Glacial Till													
43.6	End of Borehole													
1293.0														
46.9	End of Cone Test													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



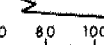
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HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

8

RECORD OF BOREHOLE No 2

W P 18-77-07 LOCATION Sta. 258+97; o/s 5' Lt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Washbore NX Casing, BXL Rock Coring COMPILED BY P.P.
DATUM Geodetic DATE October 27-31, 1978 CHECKED BY A.J.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						×	LAB VANE	W _p
1339.9	Water Level														GR SA SI CL			
0.0	Water																	
1336.5	River Bottom																	
3.4	Clayey Silt to Silt, Some Sand		1	SS	1/20'										1 7 56 36			
	Very Soft		2	TW	PM		1330											
1328.9																		
11.0	Silt		3	SS	11										0 5 89 6			
	Traces of Sand and Clay		4	SS	10		1320											
	Compact		5	SS	12													
	Grey																	
1311.5																		
28.4	Heterogeneous Mixture of Gravel, Sand, Silt and Clay, Dense to Very Dense		6	SS	40		1310								9 12 75 4			
	Glacial Till		7	SS	134													
1302.8																		
37.1	Bedrock		8	RC	Rec 100%		1300											
	Schist		9	RC	Rec EXL 100%													
	Sound																	
1293.4			10	RC	Rec EXL 100%													
46.5	End of Borehole																	

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



Missouri
Highway Engineering Division
Engineering Materials Office - Soil Mechanics Section

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

9

RECORD OF BOREHOLE No 3

W P 18-77-07 LOCATION Sta. 260+05; o/s 3' Rt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Washbore-BX Casing-BXL Rock Coring COMPILED BY P.P.
DATUM Geodetic DATE November 1-2, 1978 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1339.9	Water Level																
1337.5	Water River Bottom																
2.4	Clayey Silt Traces of Sand Very Soft to Firm		1	SS	2		1330										0 2 57 41
1322.1																	
17.8	Silt Traces of Sand and Clay Loose		2	SS	6		1320										
1313.1																	
26.8	Heterogeneous Mixture of Gravel, Sand, Silt and Clay Dense to Very Dense Glacial Till		3	SS	33		1310										23 58 17 2
			4	SS	95		1300										
			5	SS	63		1290										0 91 (9)
1283.9																	
56.0	Bedrock		6	RC	Rec												
1280.1	Sound Schist			BXL	90%												
59.8	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

*³, *⁵: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4

W P 18-77-07 LOCATION Sta. 261+00; o/s 4' Rt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Washbore-BX Casing COMPILED BY P.P.
DATUM Geodetic DATE November 3, 1978 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
1339.9	Water Level													
0.0	Water													
1333.3	River Bottom													
6.6	Clayey Silt Some Sand Soft to Firm		1	SS	3		1330							0 11 67 22
			2	SS	9		1320							0 3 81 16
1318.1	Sand and Gravel With Boulders													
21.8	Very Dense		3	RC BXL	Rec 29%		1310							
1308.1	End of Borehole													
31.8														

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 5

W P 18-77-07 LOCATION Sta. 262+03; o/s 4' Lt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Washbore-NX Casing and Cone Test COMPILED BY P.P.
DATUM Geodetic DATE November 6-8, 1978 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L			
1339.9	Water Level													
0.0	Water													
1330.3	River Bottom													
9.6	Clayey Silt Traces of Sand		1	TW	PM		1330	+3					0 6 62 32	
			2	TW	PM			+3					0 5 67 28	
			3	TW	PM									
1319.9	Soft to Firm		3A	SS	-		1320	+3						
20.0	Silt Some Clay Traces of Gravel and Sand		4	SS	6								1 1 86 12	
	Loose to Compact		5	SS	24		1310							
			5A	SS	25									
			6	SS	18		1300							
1298.1	Heterogeneous Mixture of Gravel, Sand, Silt and Clay Occasional Boulders Compact to Very Dense		7	SS	24									
	Glacial Till		8	SS	33		1290						23 55 17 5	
			9	SS	50/2"			100/9"						
			10	SS	129/7.5"		1280							
1278.0	Refusal End of Borehole Probable Bedrock													
61.9														

+3, x5: Numbers refer to
Sensitivity

20
15
10
5
0
(%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 6

W P 18-77-07 LOCATION Sta. 257+98; o/s 1' Lt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Continuous Flight Auger - BX Rock Coring COMPILED BY P.P.
DATUM Geodetic DATE November 7-8, 1978 CHECKED BY RS

SOIL PROFILE		STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1351.7	Ground Level																GR SA SI CL
0.0	Topsoil																
	Clayey Silt		1	SS	2		1350										
	Traces of Sand		2	SS	5		1340										
	Occasional Silt Layers		3	SS	5												0 4 72 24
	Soft to Firm		4	SS	5		1330										0 1 89 10
			5	SS	4												
1323.7			6	SS	47		1320										27 49 21 3
28.0	Heterogeneous Mixture of Gravel, Sand and Silt		7	SS	95												
	Very Dense		8	SS	136		1310										25 64 (11)
	Glacial Till		9	SS	125												
1304.7			10	RC BX	Rec 32%		1300										
47.0	Boulders		11	RC BX	Rec 100%												
	Bedrock Schist		12	RC BX	Rec 95%												
	Sound																
1293.2																	
58.5	End of Borehole																

+³, x⁵: Numbers refer to
Sensitivity

20
15
10
5
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 7

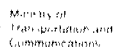
W P 18-77-07 LOCATION Sta. 263+89; 9/s 2' Lt. Line 'D' ORIGINATED BY P.P.
DIST 19 HWY Loc. BOREHOLE TYPE Continuous Flight Auger and Cone Test COMPILED BY P.P.
DATUM Geodetic DATE November 8, 1978 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	100	W _p	W	W _L		
1345.5	Ground Level													
0.0	Topsoil (Org.) Silty Sand With Gravel Traces of Clay Very Loose		1	SS	1		1340							31 33 32 4
1331.5			2	SS	2									
14.0	Clayey Silt to Silt (Layered) Some Sand Soft to Firm		3	SS	3		1330							0 19 67 14
			4	SS	1									0 10 61 29
1318.5			5	TW	PM		1320							0 12 75 13
27.0	Silt													
1314.0	Compact		6	SS	17									
31.5	End of Borehole						1310							
							1300							
1291.6														
53.9	End of Cone Test													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

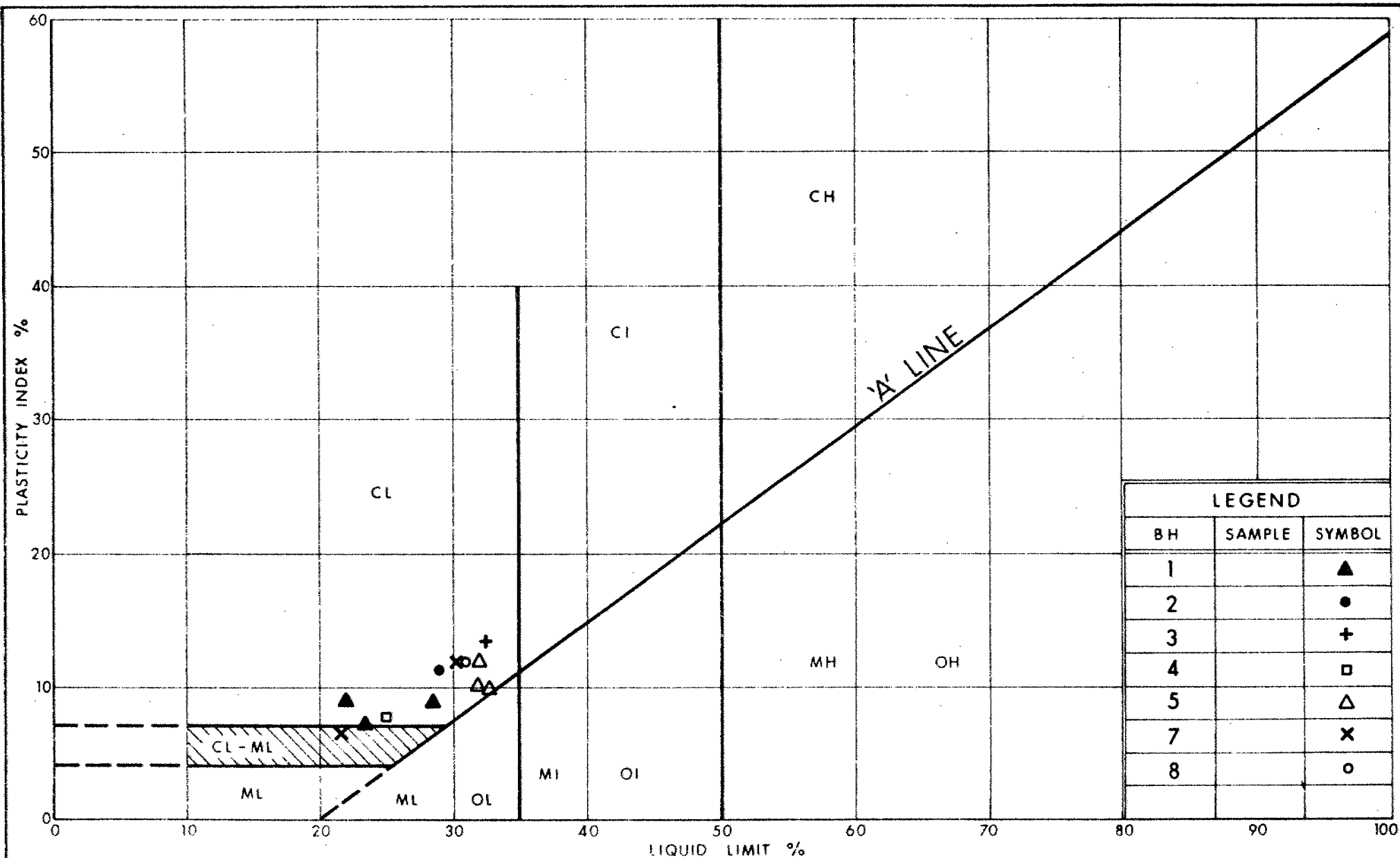
OFFICE REPORT ON SOIL EXPLORATION

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OFFICE REPORT ON SOIL EXPLORATION

+3, x5; Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

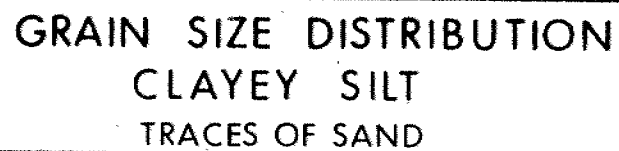


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PLASTICITY CHART CLAYEY SILT (LAYERED) SOME SAND

FIG No 1

W P 18 - 77 - 07



VOID RATIO-PRESSURE CURVES

WP. 18 - 77 - 07

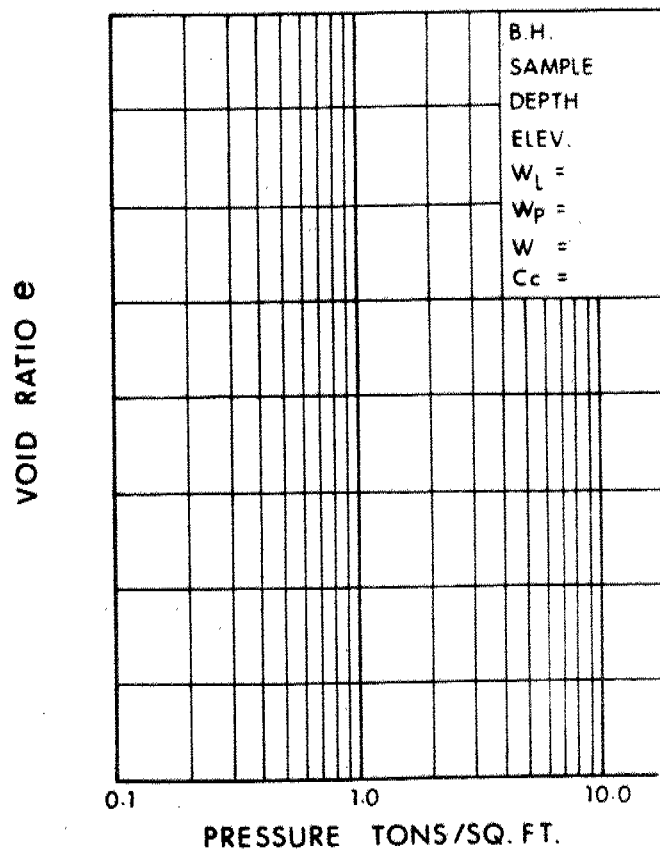
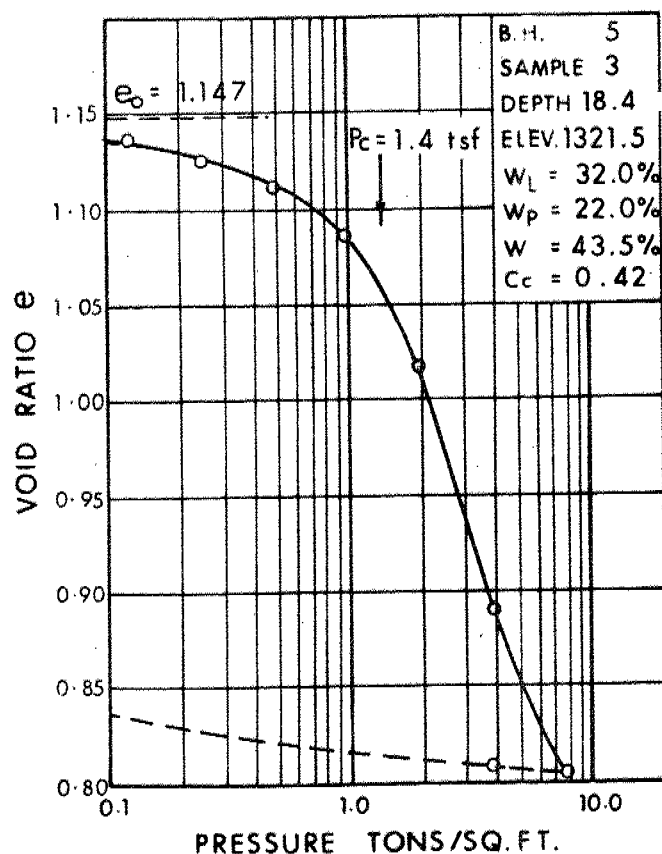
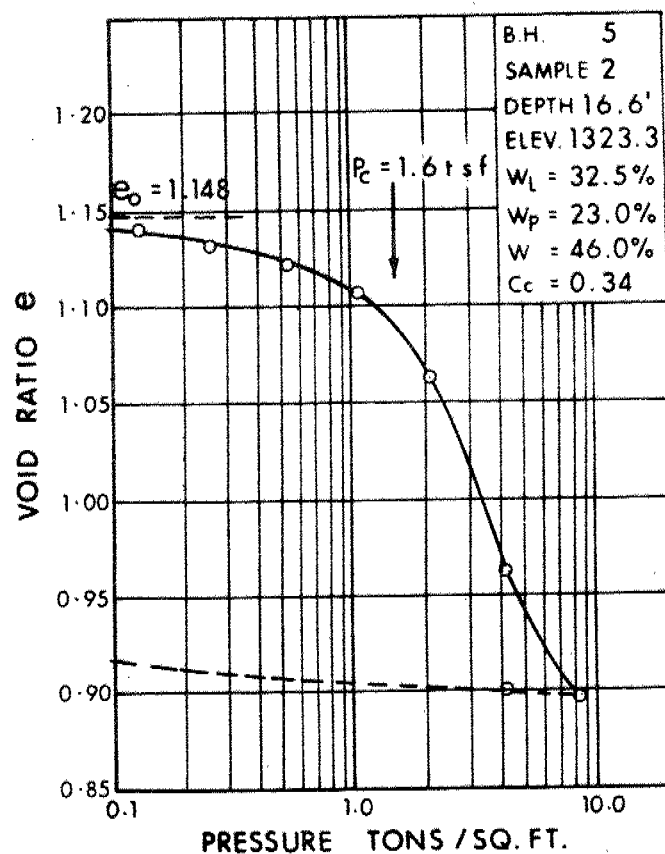
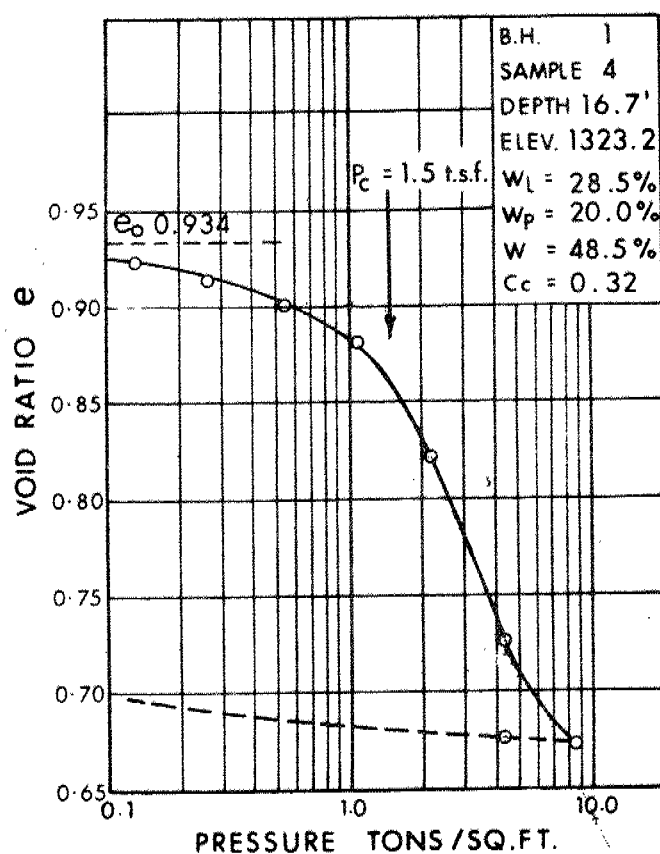


FIG. 3



GRAIN SIZE DISTRIBUTION
SILT
TRACES OF GRAVEL, SAND & CLAY

WP 18 - 77 - 07



GRAIN SIZE DISTRIBUTION GLACIAL TILL HET MIX OF GRAVEL, SAND, SILT & CLAY

WP 18-77-07